CHEMICAL ENGINEERING

OCTOBER 30, 1961

McGraw-Hill Publication / Published every-other-Monday / Seventy-five cents

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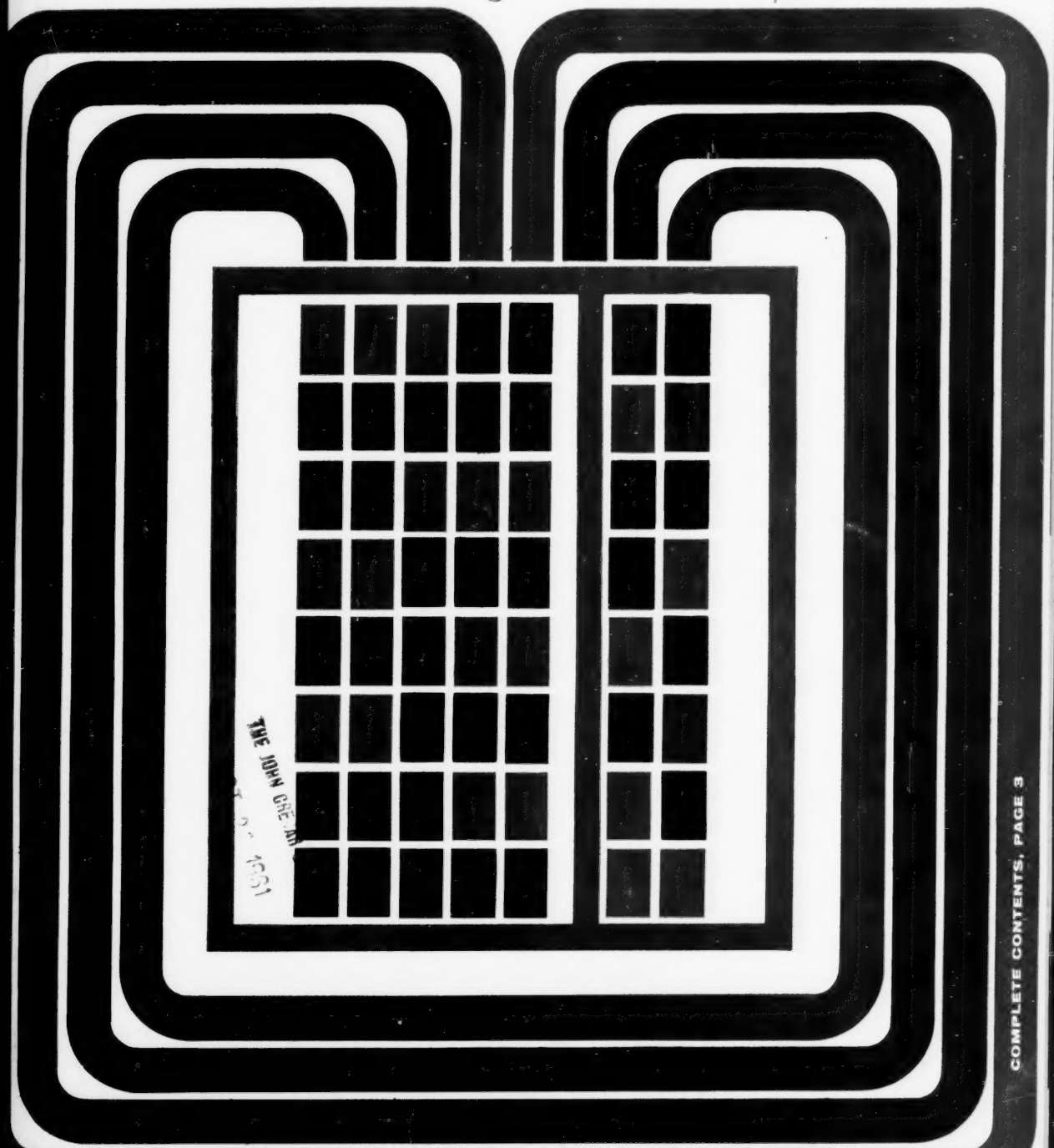

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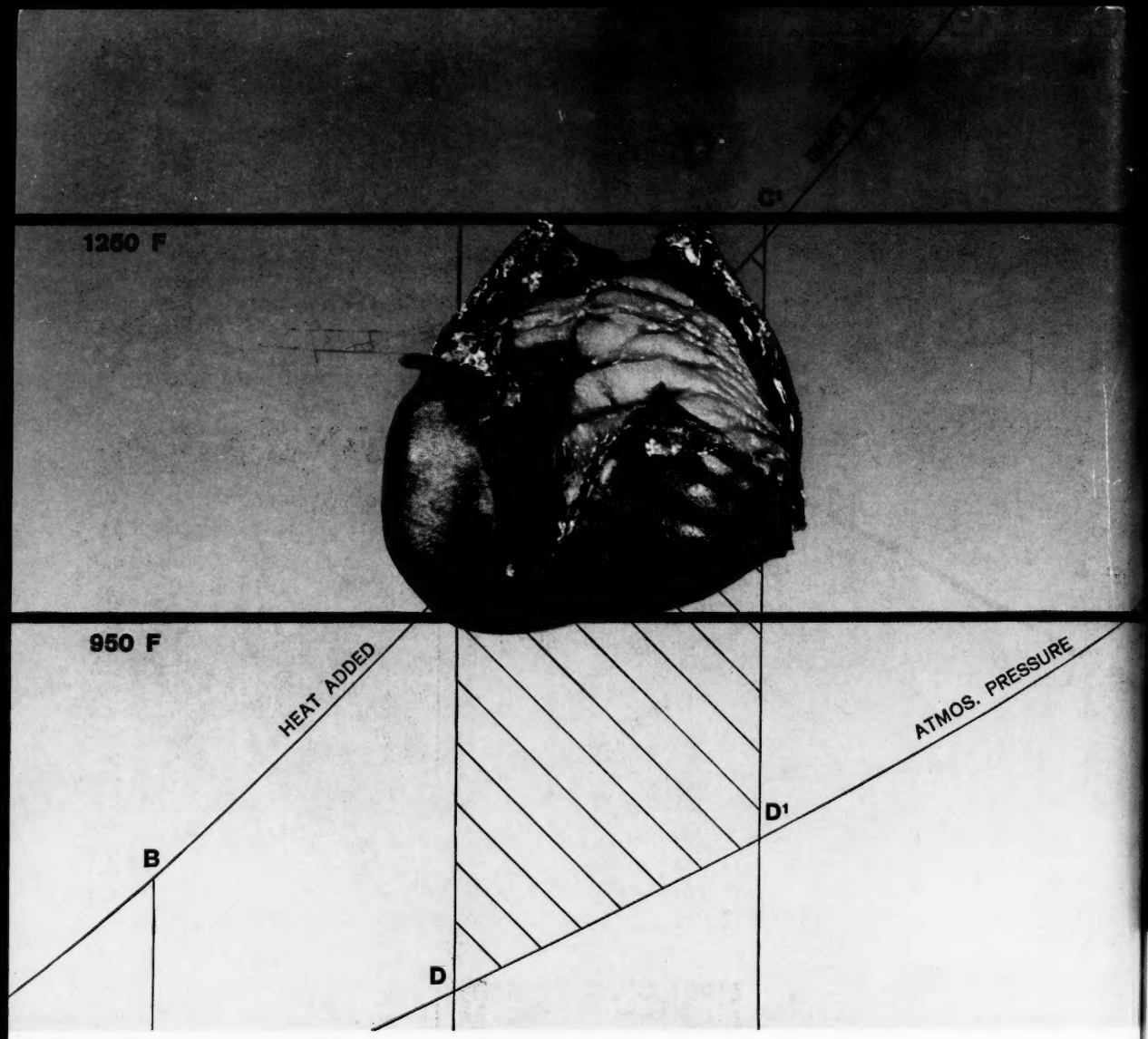

THE POWER RECOVERY "CHESTNUT"

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A proven method for taking mechanical power from process tail gas below 950F is the turbine. Taking power from tail gas above this temperature has, in the past, been a power recovery "chestnut"—too hot to handle despite its desirability. But now, Worthington offers a Power Recovery turbine that can successfully pluck the meat from this very hot "chestnut."

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In the past, use of Power Recovery turbines at the higher temperatures has been impractical. One major problem has been in mechanical design. Misalignment caused by excessive thermal expansion, higher temperature sealing, rotor construction, and forces imposed on the expander by inlet piping expansion and construction are all part of the problem. Today, Worthington has minimized them by creating a new design and using new materials.

A second major problem area that Worthington has overcome is analysis of the gas itself. Most tail gases are mixtures and their behavior is not fully plotted at the temperatures involved. But the behavior must be known before the turbine can be designed. Today, Worthington is ready t analyze the heat recovery potential of an gas or gas-steam mixture and to design Power Recovery turbine to match.

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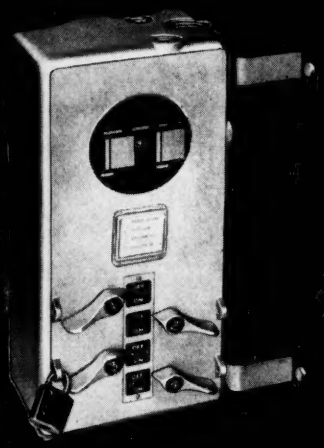

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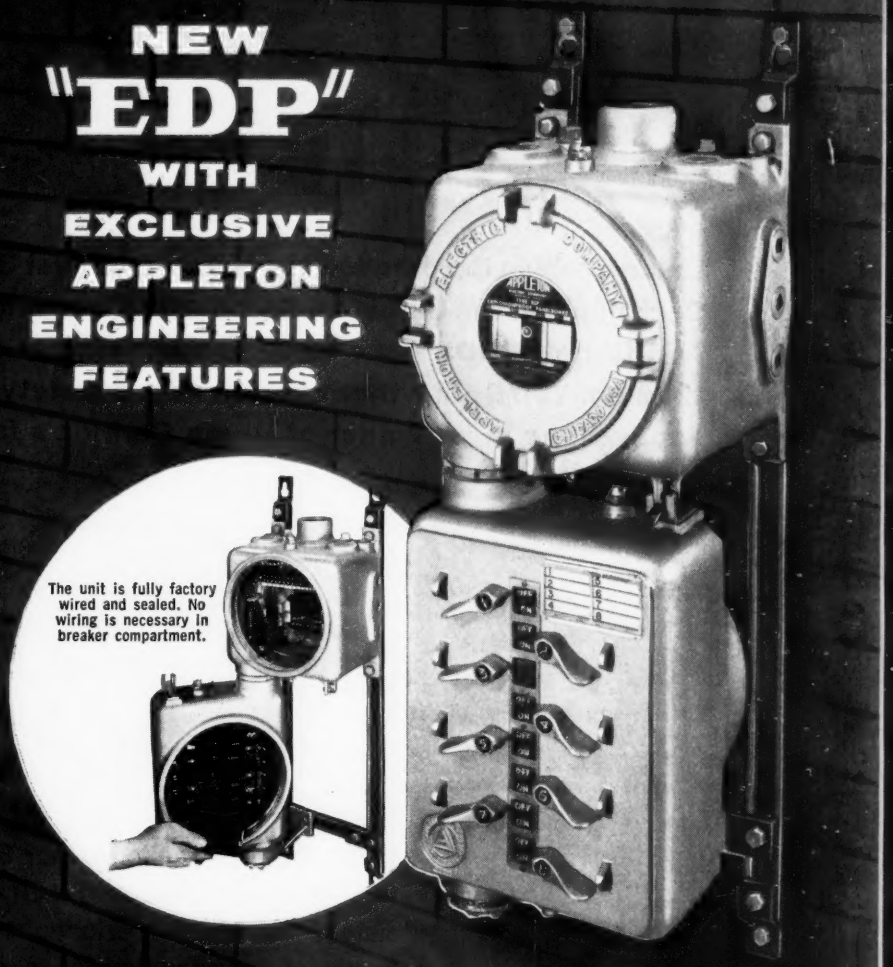

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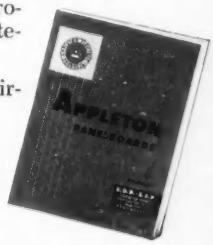

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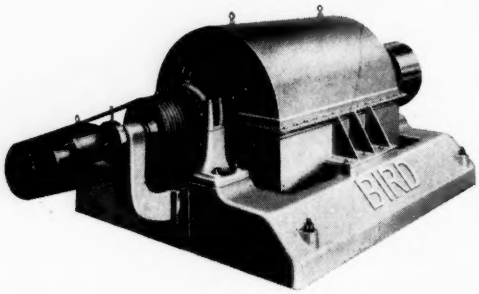

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CHEMICAL ENGINEERING

October 30, 1961

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

COVER: An abacus, symbolized at the center of the closed loops, portrays a digital computer that controls Esso R & E's new and unique pilot plant. Story on p. 97.

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VOLUME 68, NUMBER 22

Chemical Engineering (with Chemical & Metallurgical Engineering) is published biweekly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder.

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Printed in Albany, N. Y.; second class postage paid at Albany, N. Y. and at additional mailing offices. Title ®registered in U.S. Patent Office.

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Subscriptions: Send correspondence and change of address to Fulfillment Manager, Chemical Engineering, 330 West 42nd Street, New York 36, N. Y. Send notice promptly for change of address, giving old as well as new address. Enclose an address label from a recent issue of the magazine if possible. Allow one month for change to become effective.

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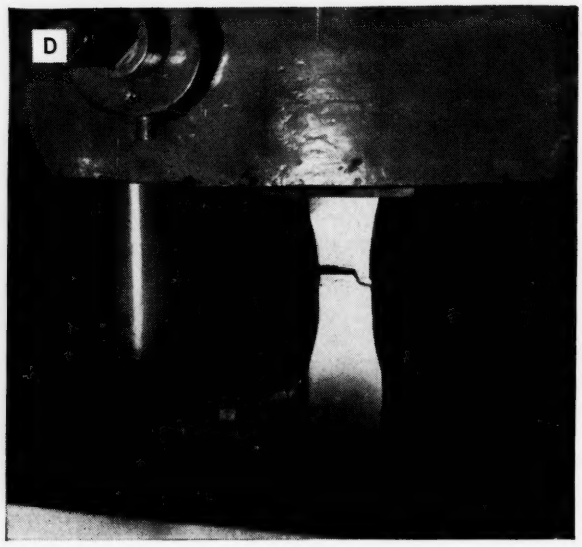

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highlights of this issue

THIS PILOT PLANT RUNS ITSELF BY COMPUTER

When Esso Research and Engineering announced a program to develop a computer-controlled pilot plant (*Chem. Eng.*, Mar. 10, 1958, p. 74), industry observers sat back to await a meaningful report on this new technology. But a large share of the technical press waxed enthusiastic about the system without any actual supporting evidence.

CHEMICAL ENGINEERING was an exception, reporting nothing beyond the initial announcement until the unique system was delivered to Esso last spring (*Chem. Eng.*, May 16, 1960, p. 71). That patience has now been rewarded by an exclusive report (p. 97) from two chemical engineers who worked on the project—one from Esso, the other from the vendor, Consolidated Systems Corp. Read how the textbookless problems that arose during development were solved, and what this technology means for CPI engineers and managers.

NEW TRENDS IN CHEMISTRY (CONTINUED)

Three important articles explore more of the new trends reported at the Armour Research Foundation and CHEMICAL ENGINEERING conference earlier this month. These are ventures into exciting and untamed fields. For example, Princeton's Pohl reveals some of the challenges of organic semiconductors (p. 104). In kinetics, where the most striking development has been an expanded resolution of the time scale, Dr. Kilpatrick says that (as usual) broader understanding will lead to narrower specialization (p. 111). And while work is still in an early stage, Pennsalt's Barth-Wehrenalp reveals important advances that have been made in developing new polymers with the heat resistance of inorganics and the pliability of organics (p. 117).

ASK PHILADELPHIA!

Adding or removing heat in a process mixing operation is tricky. Improper baffling in any mix may permit swirling and drastically reduce the efficiency of coil type heat transfer surfaces.

With viscous liquids, particular care is needed. Because stagnant zones must be avoided, baffling may have to be reduced or eliminated . . . and impeller size and speed must be chosen carefully to minimize swirling.

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AGMA MEMBER

Plant Designer vs. Supplier

Sir:

Your handling of Mr. Baukol's letter and Mr. Hitch's reply (Sept. 18, pp. 171-4) is very fine. The technique is certainly applicable to any controversy where opinion divides largely along functional lines, as in this case.

Such treatment of controversial issues in CHEMICAL ENGINEERING is certainly a contribution to the chemical process industries.

HOWARD MEHR
Dorr-Oliver Inc.
Stamford, Conn.

Pro: Role of Fire Chief

Sir:

I was amazed that the panel of experts analyzing the Stardust Chemical Co. disaster (Aug. 7, pp. 111-24) did not include a fire chief, either municipal or industrial, even though the problem involved serious fire.

Not until the discussion was nearly over did the panel get around to the role of the fire chief, and then only at the prompting of a member of the audience. The ensuing remarks of the panel members displayed either simple gross arrogance or appalling ignorance of fire protection procedures. For example:

Panelist Kling stated that Stardust will have its own fire chief who will direct operations; the local fire department will take orders from him.

This raises the question of responsibility for fire suppression. While a municipal or fire district chief may attempt to abdicate this burden or even permit his authority to be usurped, in the final analysis he alone is responsible by law; all other chief officers fall under his command. There may be some exceptions to this general thesis, and I do know that some industrial plants are built in areas where no fire protection authorities exist. Yet in the main, the local municipal fire chief is in command, and his authority is spelled out in the statutes.

Mutual aid is nothing new to fire services; many states, counties and cities are very well organized in this respect. New York State, for example, has an official agency, the Division of Fire Safety, which devotes a large part of its efforts to such a program.

DONALD M. O'BRIEN
Editor, *Fire Engineering*
New York, N. Y.

Pro: NSPE Program

Sir:

In your Sept. 4 issue (p. 6) you published a portion of a letter I had written commenting on the AIChE report on Dynamic Objectives. This I appreciate.

However, you passed over what I consider the main point of my letter—the need for the program of the National Society of Professional Engineers.

The only hope for building a better profession requires that more of the leaders of the many branches of engineering get together on their mutual professional problems. This can't be done through Engineers' Joint Council, which by law is restricted to technical fields. It can be done only if enough top-notch engineers stop fighting NSPE and join with those who are doing their utmost to build a better profession.

If any of these persons doesn't like NSPE policy, all he has to do is to join NSPE and by open, democratic methods change these policies. The door is open. It's as simple as that.

As for the pressures on NSPE to lower the bars to allow presently unqualified persons to join, let's ask ourselves if it will really help the profession. Any qualified person in most states can become registered if he makes the effort. Is that too much to ask?

ALFRED B. SABIN
Alfred B. Sabin & Associates
San Francisco, Calif.

Role of Mass Transfer

Sir:

Dr. Smoot's article on transport phenomena (Aug. 21, pp. 126-30) lucidly summarizes the work of Bird *et al.* However, the section on mass transfer analysis seems to defeat his purpose.

In Table II, he states the over-all balances for a micro system. He attempts to demonstrate how these micro balances can be used in the solution of macro problems.

But alas, in Eq. (6) we find ϕ. Is the mass transfer not included in the diffusion terms? It would thus appear that diffusion plays no role in absorption columns. Instead, absorption is due to the natural inclination of the solute to migrate from a region of "high C" to one of "low C." Bird (*op. cit.*, p. 539) has presented a proper solution of the same problem.

JOE LORENT
University of Houston
Houston, Tex.

Sir:

The solution by Bird is for bulk flow and molecular diffusion in one phase only. The concentration of the solute is known at the liquid-gas interface. Therefore, there is no need for the term ϕ representing *interphasial* mass transfer.

However, Bird's solution does not apply to the problem of absorption as I proposed it. The diffusion term (Fick's law) of Eq. (6) will account only for *intraphasial* transfer of solute; therefore the two-film theory equation was added to account for the transfer between phases. This, too, is a diffusion term, and diffusion certainly has a most important role in the solution.

L. D. SMOOT
Brigham Young University
Provo, Utah

► *Further information on this subject appeared in the second and third articles of the series (Sept. 18, p. 183 and Oct. 16, p. 187).*—ED.

CYANAMID

Chemical Newsfront

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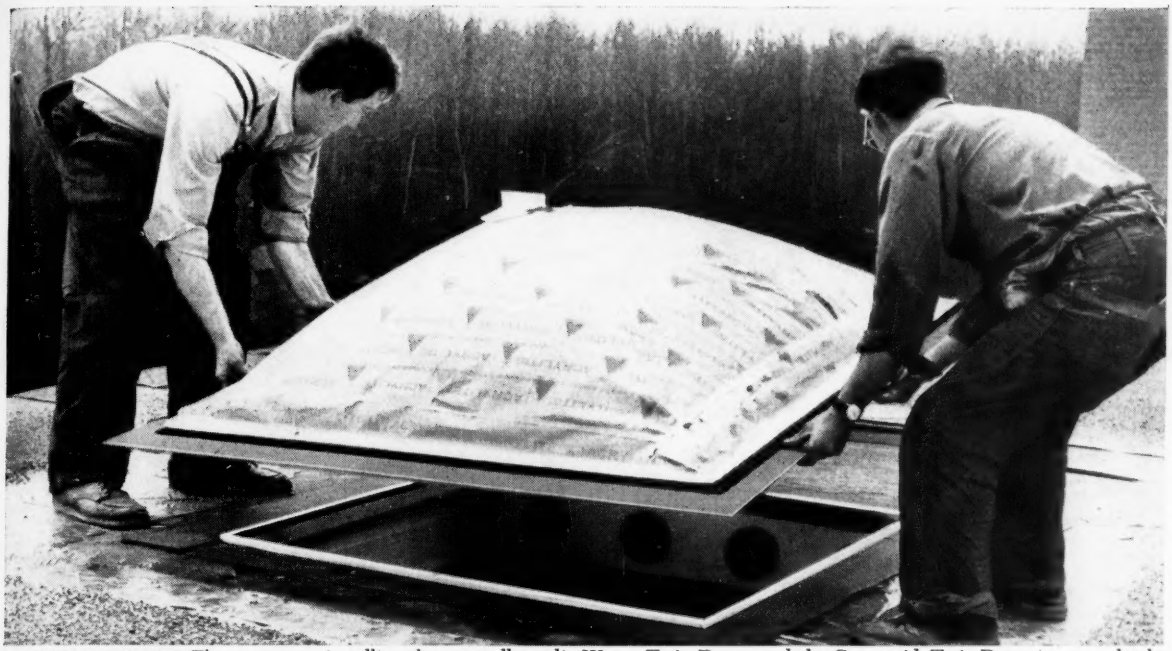

PACKAGED DAYLIGHT. These men are installing the new, all-acrylic Wasco Twin Dome made by Cyanamid. Twin Dome is a completely sealed, insulated, shatterproof, low-profile skylight with inner and outer domes available in any combination—clear, colorless, white translucent or reflective—to allow maximum control of light levels and heat gain. The domes are bonded to an aluminum nailing flange for easy installation and have an inch of "dead air" between them for exceptionally efficient insulation against heat and cold.
(Wasco Products Department)

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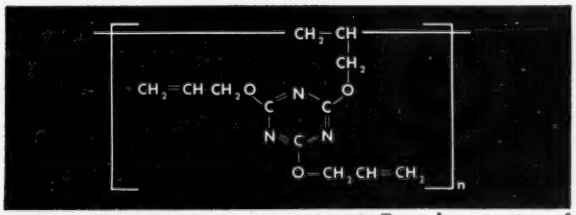

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(Market Development Department)

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USS 9% Nickel Steel reduces cost of handling low-temperature liquids

Today, more than 400 pressure vessels made of 9% nickel steel are providing economical service at temperatures down to −320°F, the boiling point of liquid nitrogen. The pressure vessels shown here are designed for liquid oxygen storage at −297°F. Low carbon, 9% nickel alloy steel was developed to provide a ductile, moderately priced steel for storing such cryogenic liquids as ethylene, methane, oxygen and nitrogen in the temperature range from −150°F to −320°F.

USS 9% Nickel Steel maintains good strength, toughness, and excellent ductility at sub-zero temperatures down to −320°F. At room temperature it has a minimum yield strength of 65,000 psi and high charpy impact values, while at −320°F, double-normalized and tempered 9% nickel steel shows a 36% increase in yield strength, and charpy keyhole impact values range from 20 to 40 ft/lbs. Since tensile properties and impact values are even better for quenched and tempered 9% nickel steel, recognition by various code groups of the suitability of such heat treatment is now being considered.

10% lower costs. Accumulated data on cryogenic vessels of 9% nickel steel suggest that minimum savings of 10% of the final erected costs can be expected from reductions in material welding and fabricating costs alone, in comparison with non-ferrous metals. Economies due to higher strength are also possible. An allowable ASME working stress of up to 23,750 psi permits reduction in vessel weight with lower unit costs.

Acceptance of 9% nickel steel in the quenched and tempered as-welded condition by code and regulatory bodies would make this steel even more attractive to designers and fabricators since the vessel would cost less to produce without stress-relieving and would be less expensive to the user.

Results of "Operation Cryogenics." Impact tests conducted late in 1960 on three full-size rectangular vessels refrigerated to −320°F, showed that 9% nickel steel vessels in the as-welded condition (not stress-relieved) could withstand impacts far beyond any likely to occur in service. Burst tests on six cylindrical vessels, also at −320°F, showed that burst pressure for the three as-welded vessels (not stress-relieved) averaged higher than that of the three stress-relieved vessels. Burst pressure for all six vessels was at least four times the design pressure. These tests proved that 9% nickel steel has the high strength, low temperature toughness, and weldability needed for cryogenic pressure vessels.

For the complete story of USS 9% Nickel Steel, including all the details of "Operation Cryogenics," write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania. USS is a registered trademark.

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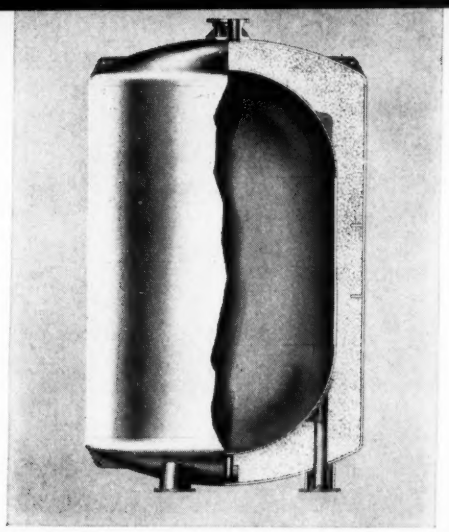

Above, cutaway view shows typical insulated 9% nickel steel pressure vessel nine feet in diameter and 16 feet in over-all length. Outer tank is structural carbon steel. **Left and below,** cylindrical pressure vessels for handling liquid oxygen at −297°F during fabrication from USS 9% Nickel Steel at Pittsburgh-Des Moines Steel Company. Vessels like these will be used by Air Reduction Company, Inc., New York. Each one holds the equivalent of 550,000 standard cubic feet of oxygen gas in liquid form, at a normal design pressure of 270 psi and was stress-relieved after welding in accordance with 1961 ASME regulations. Plate thicknesses are 0.700″ in the shell plates and 0.375″ and 0.350″ in the hemispherical head segments. These vessels are designed and stamped in accordance with the ASME code. Vessel at left is ready to be insulated and inserted in its carbon steel shell, while, below, a welder completes a bottom head.

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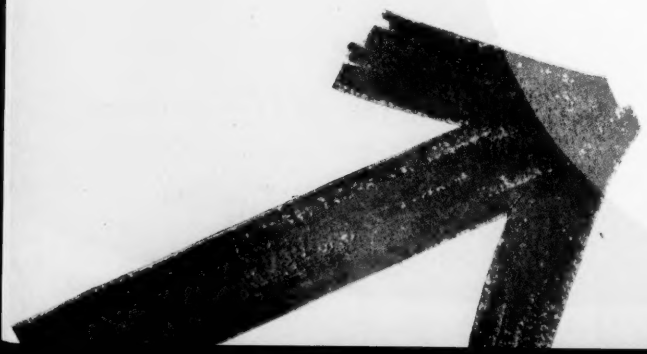
...a new pattern of control for CONTROLLED DISPERSION

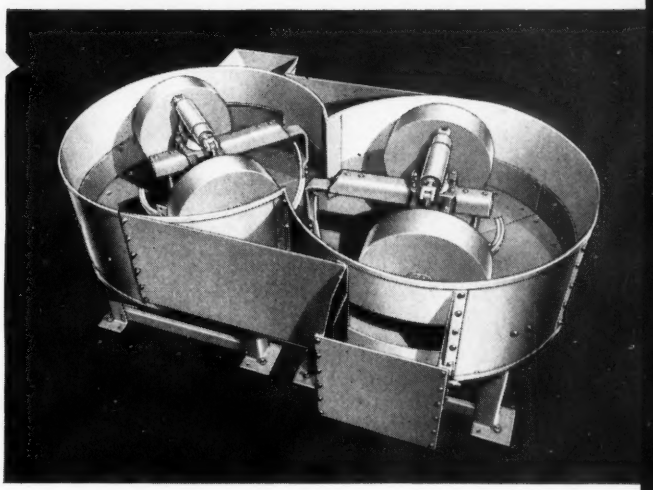
Continuous mulling starts here

The unique figure 8 pattern holds the key. In each pan, materials are subjected to the same mulling action employed in a batch muller. However, it is the continuous and prolonged *recirculation* of material between the pans which assures a thorough, controlled and continuous blending action . . . equal to that achieved in a batch muller. With *many* materials, quality is superior!



SIMPSON MULTI-MULL®

. . . the continuous muller



How and why it offers new opportunities for better, faster mixing of dry and wetted/solid materials

The achievement of intimate and controlled mulling at a high and continuous rate of production comes as a result of almost 20 years of development. Several continuous muller prototypes were abandoned before the Simpson Multi-Mull—a modification of the basic mulling concept which has been applied to Simpson equipment for over 50 years—demonstrated its mixing efficiency through plant usage. Now operational, the last unit shipped will bring total Multi-Mull tonnage to 14 million this year. Multi-Mull users are reporting benefits which are of significance to *anyone* who now uses a muller . . . and to many for whom batch mulling practice was not practical before:

ECONOMY—a welcome end to expensive, troublesome and space consuming batch preparation equipment.

CONTROL—over moisture and other additives, not possible in many batch mixing methods, which permit new quality control standards.

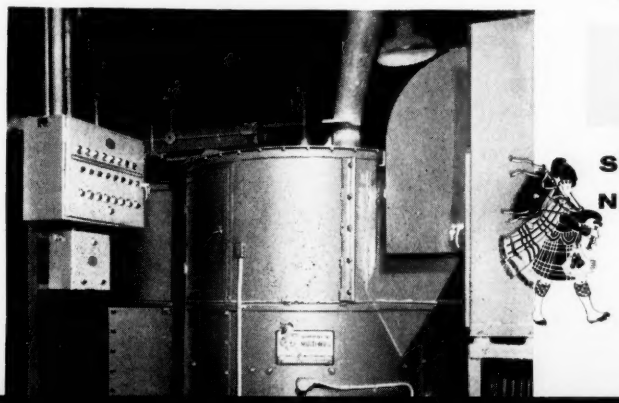
SPEED—the ability to reduce preparation time in direct ratio to the number of charge and discharge cycles needed previously.

PRODUCTION—continuous mulling boosts production with a *decrease*, rather than an increase, in equipment and floor space requirements.

QUALITY—the quality of continuously prepared material is equal in every way to that prepared by batch methods. Many users report *superior* prepared qualities and decided savings in raw materials.

APPLICATION—no cure-all, the Multi-Mull was introduced to do *certain* jobs better, faster and at lower cost than previous methods—and to widen the scope of application for the mulling principle of mixing.

It will pay you to have a *Mix-Muller man* tell you more about Multi-Mull--because the era of continuous mulling is here, *now*. Write for details —there is no obligation, of course.



See Multi-Mull in action

28th Exposition of Chemical Industries

SIMPSON *MIX-MULLER* DIVISION

NATIONAL ENGINEERING COMPANY

636 Machinery Hall Building

Chicago 6, Illinois

P461-S

MID-SOUTH CHEMICAL REPORTS...

Ammonia refrigerated at less cost with Trane Air-Cooled Exchangers

Air-cooled condensers eliminate costly water supply, maintenance costs.

The trend toward the use of refrigerated vessels—rather than full pressure—for the processing and storage of liquefied gases is indicated by this new installation.

This Mid-South chemical plant at North Pekin, Illinois uses five TRANE Fluid Coolers —four 15-ton "holding" refrigeration condensers and one 65-ton "filling" refrigeration condenser.

Lower Construction Costs

Refrigerated tanks at Mid-South Chemical are designed for lower pressures and constant maintenance of product temperatures. The tanks, by Chicago Bridge & Iron, are built of lighter steel. And savings on steel were much greater than the cost of insulation and refrigerating equipment. TRANE units helped make these savings possible.

Lower Operating Costs

Another reason TRANE air coolers were selected by Mid-South Chemical was to eliminate the high and continuing costs of operating water-cooled equipment. If water-cooled equipment were used, 120 GPM of treated water would be required, frequent cleaning of the shell-and-tube condensers would be necessary, and a cooling tower would have had to be built.

Lower Maintenance Costs

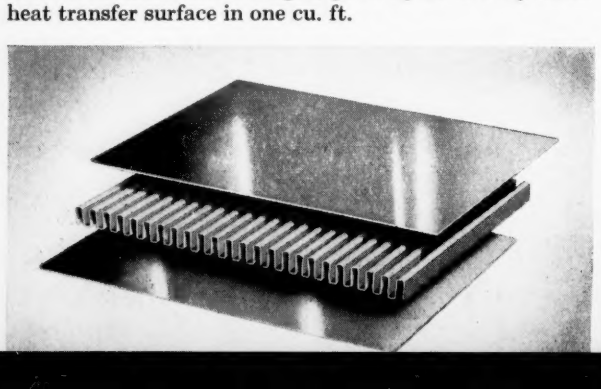
TRANE Fluid Coolers normally need only periodic cleaning of the fin-tube surface. No need for costly maintenance crews . . . spare parts . . . special maintenance facilities and equipment to combat scaling, fouling and corrosion of water-cooled equipment.

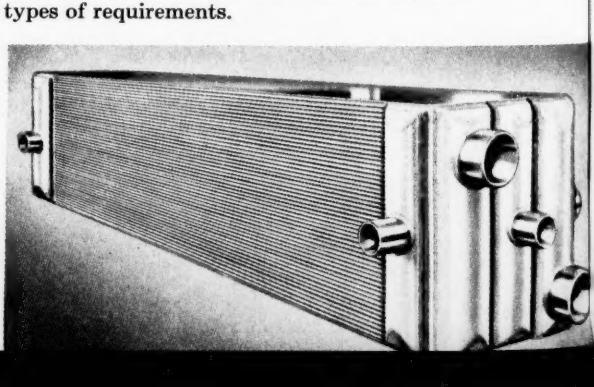
WANT MORE FACTS?... For additional information on any heat transfer problem see your nearby TRANE Sales Office—or write direct to TRANE, La Crosse, Wisconsin.

TRANE Brazed Aluminum Heat Exchangers—for low temperature processing of gases and liquids

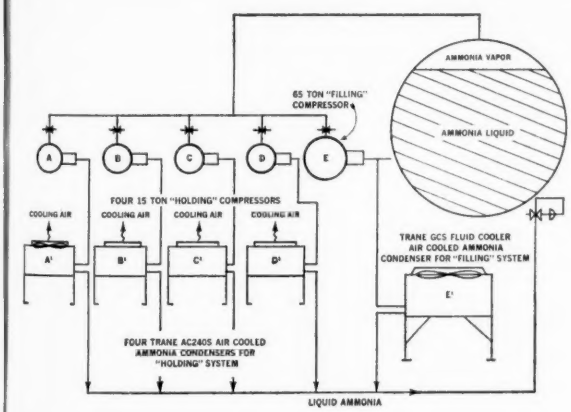
Lightweight, compact TRANE Brazed Aluminum consists of corrugated aluminum sheets brazed together to form a stack of layers which form individual passages for the flow of fluids or gases. Provides up to *nine times* the surface per cubic foot of shell-and-tube exchangers! TRANE Brazed Aluminum Exchangers pack up to 450 sq. ft. of heat transfer surface in one cu. ft.

Headered for 5-stream operation, this TRANE Brazed Aluminum Heat Exchanger can handle as many as five fluids simultaneously. Units are available for either cross-flow or counter-flow operation. Surface can be fabricated in a wide variety of shapes and sizes to meet all types of requirements.





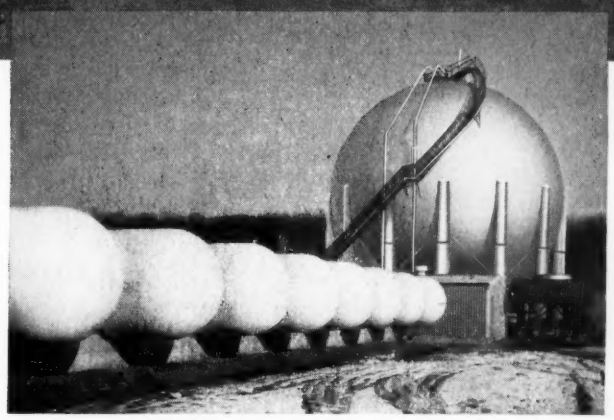
TRANE Fluid Coolers. Shown here are three of the four TRANE Fluid Coolers used in Mid-South Chemical's North Pekin operation. TRANE Fluid Coolers have a life expectancy of 15 to 20 years—compared with 7 to 10 years for cooling towers. TRANE has had over 30 years of heat transfer experience.



Basics of Mid-South Chemical's procedure

FILLING—Liquid ammonia at ambient air temperatures is transferred from conventional high pressure storage to Hortonsphere. During transfer a portion of this liquid flashes to vapor. This vapor is compressed, condensed in TRANE Fluid Coolers and returned to the Hortonsphere.

HOLDING—A portion of the liquid ammonia stored at 36°F in the Hortonsphere evaporates to vapor due to solar heat pickup. This vapor is re-compressed, and condensed in TRANE Fluid Coolers—and the liquid is returned to storage.



Huge storage capacity is provided by the Hortonsphere. This unit has a 28,000-barrel capacity—equivalent to about 44 blimps like those in foreground.

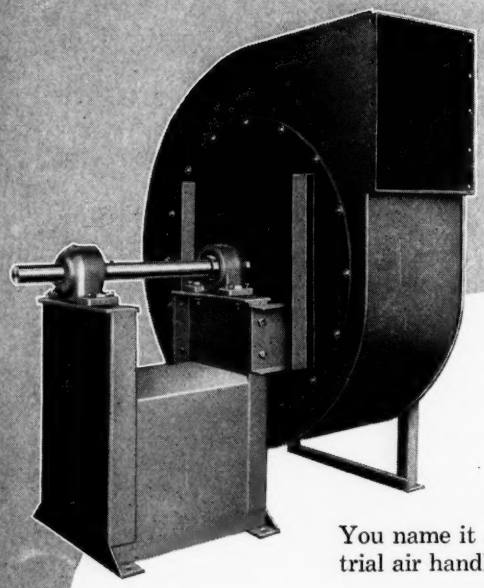
For any air condition, turn to

TRANE

Manufacturing Engineers of Air Conditioning, Heating, Ventilating and Heat Transfer Equipment

THE TRANE COMPANY, LA CROSSE, WIS. • SCRANTON MFG. PLANT, SCRANTON, PA. • CLARKSVILLE MFG. PLANT, CLARKSVILLE, TENN. • SALT LAKE MFG. PLANT, SALT LAKE CITY, UTAH • TRANE COMPANY OF CANADA, LIMITED, TORONTO • 101 U.S. AND 20 CANADIAN OFFICES.

How does industry rate CLARAGE?



EXAMPLE:
Over 1000 Clarage fans of this type are serving one manufacturer alone.

RE-ORDERS . . . RE-ORDERS . . . RE-ORDERS

You name it . . . Clarage has it for virtually any industrial air handling assignment.

Take the Type XL Fan shown. It's built in 16 sizes and four arrangements for volumes to 130,000 CFM, temperatures to 1000°F., pressures to 18″. AMCA Certified Rating Seal applies to the three different wheels available —open, rim, and backplate types.

In the Clarage tradition of heavier duty construction, here is *quality* equipment assuring better results over a longer period of service. No wonder all 100 of America's 100 largest industrial corporations are Clarage users. If you too are after air handling and conditioning equipment that has what it takes—in every respect—contact our nearest sales engineering office.

CERTIFIED
RATINGS
Certified Ratings are the result of tests made by the manufacturer in accordance with Standard Test Codes adopted by the Air Moving and Conditioning Association, Inc. Air Moving and Conditioning Association, Inc., is successor to Industrial Unit Heater Association, National Association of Fan Manufacturers, Inc., and Power Fan Manufacturers Association.
AUTHORIZED BY
AMCA
© 1957 AIR MOVING AND CONDITIONING ASSOCIATION, INC.

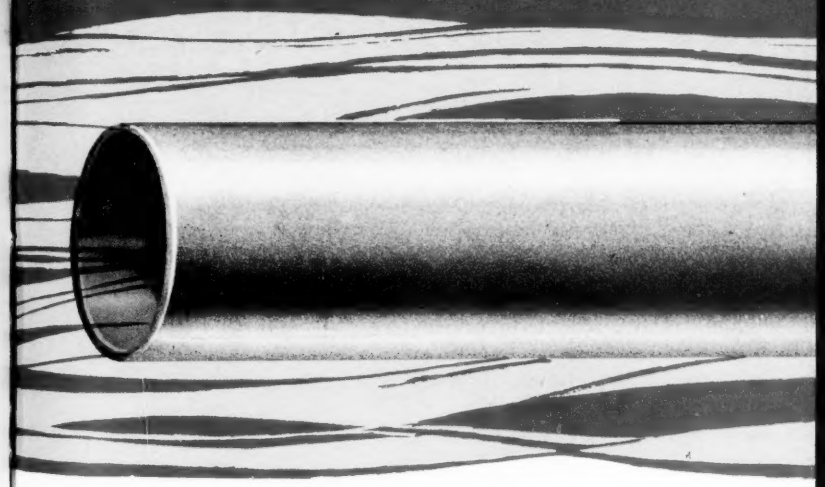
Dependable equipment for making air your servant

CLARAGE FAN COMPANY

Kalamazoo, Michigan

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

WOLVERINE TITANIUM HEAT EXCHANGER TUBE IS CORROSION RESISTANT IN ALL THESE SERVICES



In addition to great corrosion resistance Wolverine titanium heat exchanger tube also offers extreme lightness and high strength in relation to weight. The combined results of these advantages are illustrated in the following comparative heat exchanger costs table. See how they can add up to *real savings* for your company.

METAL	A	B	TITANIUM
a. Cost per pound	$0.80	$3.00	$10.00
b. Pounds required	1,000	1,200	600
c. Material cost (a x b)	$ 800.00	$3,600.00	$6,000.00
d. Fabrication cost	$3,000.00	$3,500.00	$3,500.00
e. Total equipment cost (c + d)	$3,800.00	$7,100.00	$9,500.00
f. Cost ratio	1	1.92	2.5
g. Average service life	1 yr.	2 yrs.	5 yrs.
h. Cost per service year (e ÷ g)	$3,800.00	$3,550.00	$1,900.00

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. R, 17232 SOUTHFIELD RD., ALLEN PARK, MICH.
TUBEMANSHIP in Copper—Copper Alloys—Aluminum—Special Metals
PLANTS IN DETROIT AND INKSTER, MICHIGAN AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES

CHEMICALS & SALTS

Ammonium Chloride
Ammonium Hydroxide
Barium Chloride
Calcium Chloride
Calcium Hypochlorite
Carbon Tetrachloride
Copper Sulphate
Cupric Chloride
Ferric Chloride
Hydrogen Peroxide
Hydrogen Sulfide
Manganese Chloride
Magnesium Chloride
Mercuric Chloride
Nickel Chloride
Potassium Chloride
Sodium Carbonate
Sodium Chlorate
Sodium Chloride
Sodium Hypochlorite
Sodium Nitrate
Sodium Phosphate
Sodium Sulphide
Stannic Chloride
Sulphur Dioxide
Zinc Chloride

ACIDS

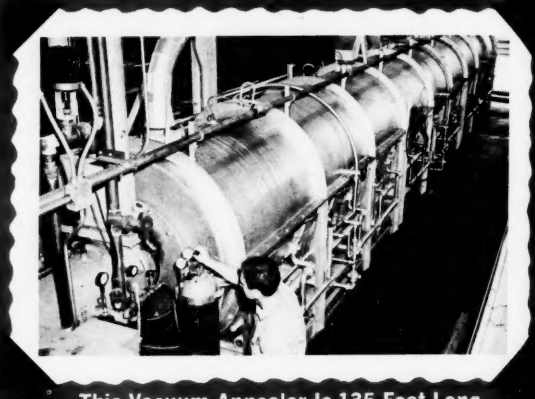
Acetic Acid
Acetic Anhydride
Chloroacetic Acid
Chromic Acid
Citric Acid
Lactic Acid
Nitric Acid
Oxalic Acid, Aerated
Phosphoric Acid
Stearic Acid
Tannic Acid
Tartaric Acid

MISCELLANEOUS

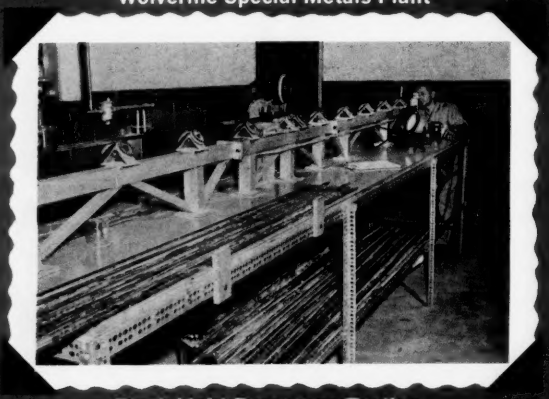
Chlorinated Water
Chlorine Gas, Wet
Chloroform
Formaldehyde
Phenol
Salt Brine
Vinegar & Salt
Water, Sea or Salt

A WORD ABOUT OUR FACILITIES

Wolverine Special Metals Plant



This Vacuum Annealer Is 135 Feet Long



Black Light Boroscope Testing

Air Gauge Test For Dimensional Accuracy

In Inkster, Michigan, Wolverine Tube operates the largest plant in the United States devoted exclusively to the production of tubing from special metals such as titanium and zirconium.

This is of major importance to tubing users. For, example, a separate facility such as this is invaluable in the minimization of alloy contamination–a highly desirable end result in tubing manufactured from special metals.

In addition to these special metal facilities Wolverine Tube, at its headquarters in Allen Park, Michigan, also maintains the tubing industry's largest research and development plant. Thus, Wolverine customers are assured of the very latest technological advances in all areas of tube manufacturing.

Because of these unique facilities you can be certain that Wolverine Tube can meet your tubing requirements–whether they be for seamless tubing manufactured from titanium and zirconium or from nonferrous metals and alloys. Write for complete information . . . or, ask your Wolverine Tube salesman – HE KNOWS!

FILL IN AND MAIL FOR COMPARATIVE ANALYSIS

Gentlemen:

We are interested in the possibility of using titanium heat exchanger tubing in our heat transfer operations. Will you please have your Heat Transfer Specialists analyze the following technical data and advise us if Wolverine titanium heat exchanger tube would be practical under the following conditions?

1 What is metal or alloy presently used?_____

O.D. and wall thickness?_____ Quantity?_____

2 Describe corrosive product with percent of concentration and tem

perature of normal use._____

3 What is maximum temperature of corrosive product?_____

4 What is operating pressure?_____

5 What is present tube life?_____

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. R, 17232 SOUTHFIELD RD., ALLEN PARK, MICH.
TUBEMANSHIP in Copper—Copper Alloys—Aluminum—Special Metals

NUCLEAR GRAPHITE NEWS
from NATIONAL CARBON COMPANY

DIVISION OF UNION CARBIDE CORPORATION, 270 PARK AVENUE, NEW YORK 17, N. Y.
OFFICES: Birmingham, Chicago, Houston, Los Angeles, New York, Pittsburgh, San Francisco. In Canada: Union Carbide Canada Limited, Toronto

NO OTHER MATERIAL HAS SO MANY USEFUL NUCLEAR PROPERTIES

- EXCELLENT STRUCTURAL MATERIAL
- RESISTS CORROSION
- RESISTS THERMAL SHOCK
- EASILY FABRICATED
- HIGH MODERATING QUALITIES
- STRENGTH INCREASES WITH TEMPERATURE RISE

GRAPHITE CORE FOR HANFORD NPR COMPLETED BY NATIONAL CARBON

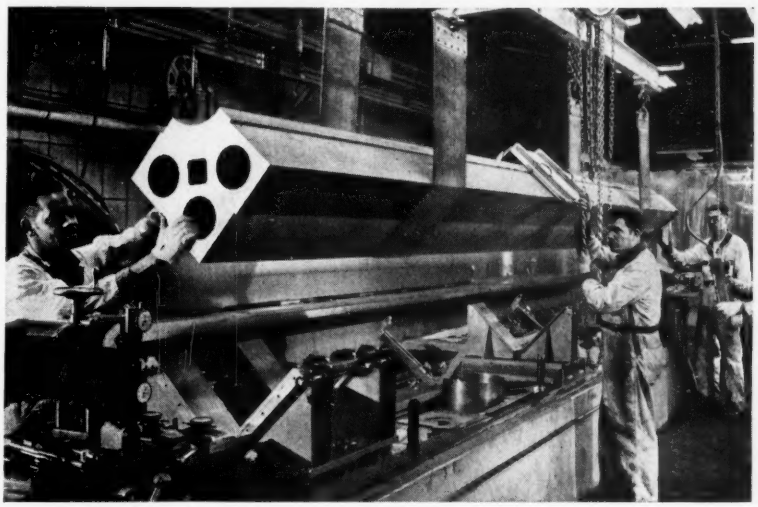
Loading last pallet of moderator bars for the NPR

The task of producing and machining 5 million pounds of high-purity nuclear graphite for the New Production Reactor at Hanford, Washington, has been completed by National Carbon Company.

The entire output was machined to close tolerances, with the thousands of moderator bars ranging in size from 2 x 3 x 48 inches to 6 x 6 x 48 inches. Total ash content was less than 10 ppm.

The New Production Reactor core is another outstanding achievement by National Carbon for the nation's growing reactor program.

4400-lb. graphite columns machined to exacting tolerances for EGCR



Swinging near-20-foot-long EGCR moderator column of "National" nuclear graphite into position for inspection after boring of fuel channels through entire length.

Machining by National Carbon Company of 120 graphite moderator and reflector columns comprising the Experimental Gas Cooled Reactor for the AEC at Oak Ridge, represents a major accomplishment in the production of nuclear components.

General machining specifications for the giant-size columns, designed for the 15-foot, 10-inch diameter core of the EGCR, called for a 125-microinch surface finish. The columns are the longest pieces of nuclear graphite ever produced.

Each moderator column, before machining, measured approximately 20 feet long by 17½ inches square, and weighed some 4400 pounds. Initial machining reduced each column to 16.3 inches square by 19 feet, 4 inches long, with final weight ranging from 2250 to 3600 pounds.

Aside from the boring of numerous precision holes of varying diameters and lengths—such as experimental, control rod, and flux scanning channels; neutron source and thermocouple holes—the most remarkable feat of machining was the boring of the fuel channels. In this operation, 234 holes, 5.25 inches diameter, were bored through the entire length of the columns, with hole diameter held within 0.030-inch, and hole location at each end within 0.010-inch.

After completion of precision machining, each piece passed a purity and flexural load test and was carefully packaged and safely delivered to the customer's plant site.

"National" and "Union Carbide" are registered trade-marks for products of
NATIONAL CARBON COMPANY
UNION CARBIDE

MECHANICAL SIMPLICITY MEANS FAR LESS COST!

F-M ROTARY COMPRESSORS

More and more, industrial leaders are looking-to (and buying) Fairbanks Morse leadership in Compressor design. Why? Because the unique, mechanical simplicity of this *rotary* design combines maximum efficiency and reliability with low initial cost—low maintenance requirements—minimum operating costs. *And skid-mounting* cuts installation time—puts you on stream faster.

The advanced design of the F-M Axial Flow Rotary Compressor features *helical-shaped* rotors for smooth, economical compression . . . with oil-free delivery, surge-free operation on a wide variety of gases.

F-M Rotary Compressors have no reciprocating parts, no valves, no metal-to-metal contact in the compression chamber. Result? Minimum "down-time" expense. They save space—produce minimum vibration—provide stable performance with speed flexibility. Every Rotary Compressor built features famous Fairbanks Morse quality craftsmanship.

With capacities up to 21,000 cfm—and pressures up to 250 psig, F-M Rotary Compressors are a versatile asset to many operations. Discover how they can step up the efficiency of *your* operation . . . and cut maintenance and installation costs as well. Write: **Fairbanks, Morse & Co., Director of Marketing, Compressor Division: Beloit, Wisconsin.**

THESE INDUSTRIAL LEADERS HAVE BOUGHT F-M LEADERSHIP IN COMPRESSOR DESIGN!

(What Benefits Them Can Benefit YOU)

The Algoma Steel Corporation, Limited
American Metal Climax, Inc.
C F Braun & Co.
Celanese Chemical Co.
Copolymer Rubber & Chemical Corp.
Cyanamid of Canada, Ltd.
Deere & Company
Foster Wheeler Corporation
M. W. Kellogg Co.
Monsanto Chemical Co.
The Ralph M. Parsons Company
Phillips Chemical Co.
Scientific Design Co., Inc.
Shell Chemical Company
St. Paul Ammonia Products Co.
Union Carbide Chemicals Company
United Refining Co.

Skid-Mounted, Tandem Rotary Compressor ready for installation at Deere & Company, Waterloo Tractor Works.

Model 200L3/132L3 Fairbanks-Morse Rotary Air Compressor for 12,000 cfm, 110 psig. with 2600 h.p. steam turbine drive.

FAIRBANKS MORSE
A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY

"Erb" is a verb...

"ERB" IS A WORD OF ACTION . . . more pertinently, Paul Erb, CHEMICAL ENGINEERING's circulation manager. You never met a man more active in *your* interests. Paul does a lot of thinking about you, your job and its demands . . . especially its informational needs. He's a fellow engineer (BSChE, Northwestern). Paul taught at Northwestern, but he's also labored in your vineyard . . . with DuPont, Dorr-Oliver, Culligan, Portland Cement Association. Their loss is your gain.

Oh, he has his faults. What a fusspot! Some folks who are dying to get CE, mail him mash notes and money, and suddenly he's as suspicious as a bridegroom's mother-in-law . . . *"Where do you work? What do you do? Got a title? How big is your plant? What does it make?"*

If the answers don't check out back goes their cash.

"Thanks, but no thanks. We're just not meant for each other."

Maybe you've noticed, how Paul's especially nosey about your influence on what goes on in your plant or office. He insists that by virtue of your engineering training and experience, you rate high as a technical decision-maker. And because so many leading suppliers to the Chemical

Process Industries agree with Paul, it's possible for us to deliver 26 issues of this journal to you for such a modest subscription fee. **But just like yourself,** these advertisers want to know what value they get for their money. So it's ABC that an independent somebody has to keep score. And somebody does, regularly and scrupulously . . . *the Audit Bureau of Circulation.* Your friend Erb's got to be a tidy housekeeper, because their auditors poke into all corners to gather, study, post, tally, review, assess and publish the records on you, multiplied by over 50,000 other CE subscribers.

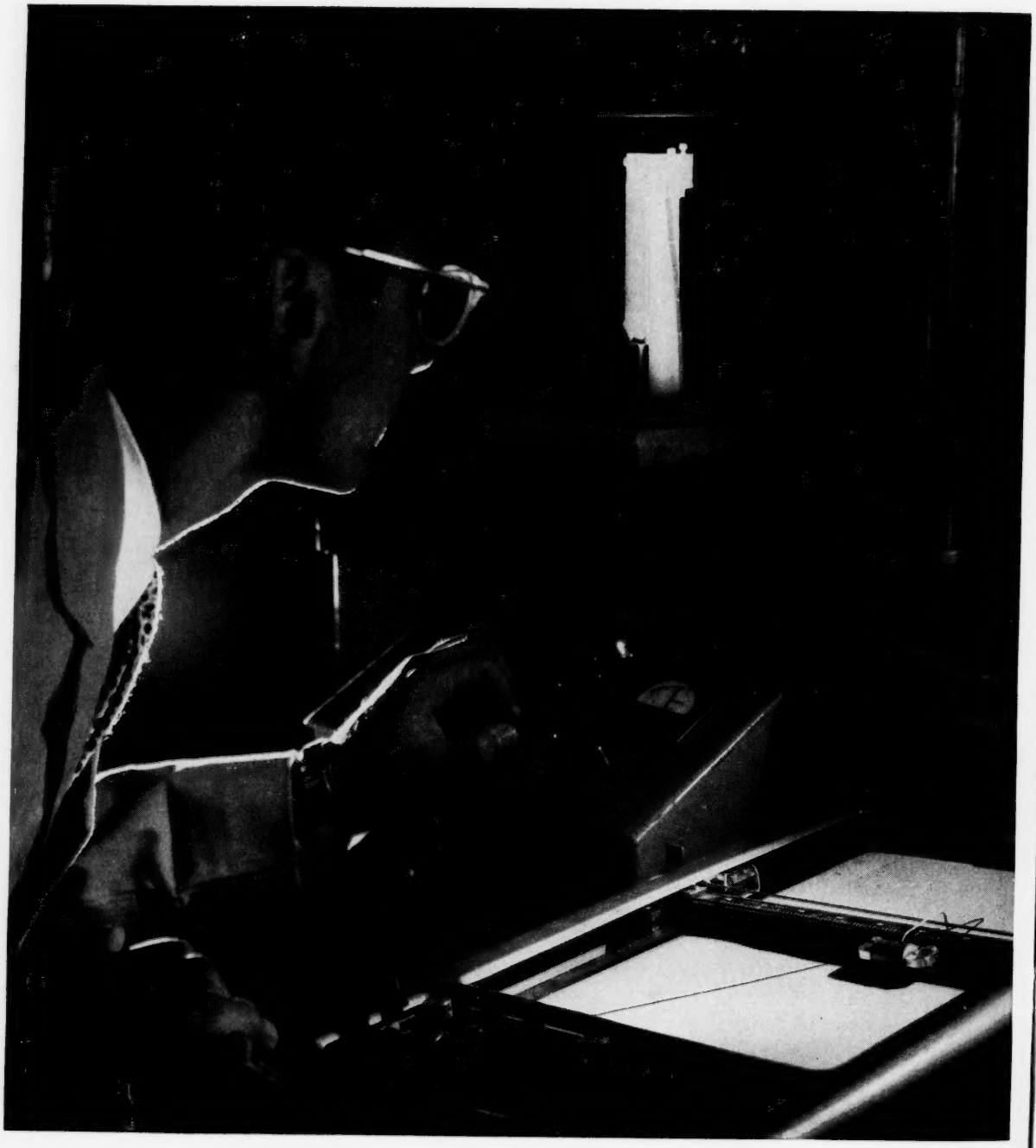
To them you may be a statistic, but you're very much an individual to Paul. You're his boss, and he knows it. On Page 3 of every issue, CHEMICAL ENGINEERING makes an unconditional guarantee: *"The publisher, upon written request from any subscriber, agrees to refund the part of the subscription price applying to copies not yet mailed."* Therefore, each time you renew your subscription, you acknowledge that what Paul promised, CE has fulfilled.

This is the second of a series about some of the people who work for you and your magazine . . .

CHEMICAL ENGINEERING

A McGRAW-HILL PUBLICATION

How controlled stress makes Glasteel™



strong

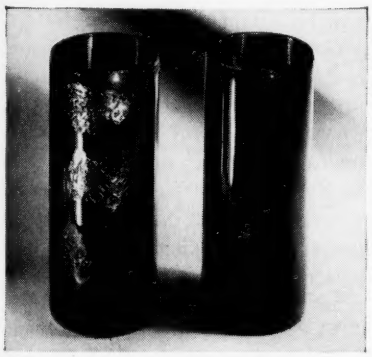
If you're concerned about the possibility of a glassed-steel vessel crazing from thermal shock . . . if you've had doubts about its ability to stand up to mechanical shock . . . read on to learn how stress data recorded by the research apparatus at left are translated into structural strengths.

The glowing sample of Pfaudler Glasteel has just undergone a stress-strain analysis. Differential expansion between glass and steel was recorded during controlled heating. Reason? To determine how much compressive stress is present in the glass.

This stress, called a compressive cushion, is *designed into* Glasteel to permit it to bend, stretch, breathe — absorb thermal shock.

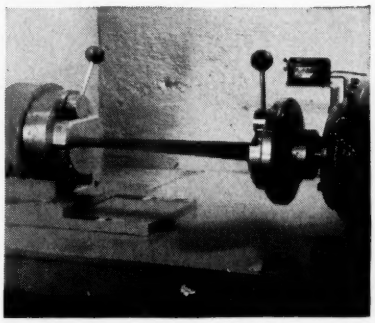
And the precise stress-strain tests which we employ permit us to predict and control the amount of compressive cushion in Glasteel over the complete operating-temperature range of a fabricated vessel.

260°△T. Controlled stress in Glasteel gives you the thermal protection of a 260° differential between product and jacket media at an operating temperature of 250° in all vessels through 2000 gallons. (We consider this a safe recommendation because it contains a very generous factor of three, based on carefully controlled laboratory experiments.)



In spite of an unusually high 455° thermal shock, no damage was done to the lab sample of Glasteel pipe at right, glassed with today's standard Pfaudler glass. Pipe at left was glassed with our previous standard.

Locked together. Glasteel as a material of construction is strong in other ways, too. The bond between the glass and steel, created by chemical action during firing, locks the components firmly together. Like this:



Even though the Glasteel bar has been twisted to the elastic limit of the steel, the glass-to-steel bond and the glass itself remain intact.

Bolt torque test. So strong is Glasteel that in a bolt torque torture test on a glassed flange, the steel portion of the flange yielded before the glass.

More tests. In point impact tests, Glasteel is 2½ times more resistant than safety plate glass. Under conditions of erosion-corrosion, it is more abrasion resistant than most metals.

On both the Knoop and other hardness scales, the glass component in Glasteel is harder than the common metals.

Summing up. When you specify Pfaudler Glasteel process equipment, you want excellent acid-alkali resistance. You get it. In addition, you get a compressive cushion to stand up to thermal and mechanical shock, a virtually indestructible bond between glass and steel, a hard, nonporous product-contact surface. And the assurance that our specifications are the accumulative result of extensive lab tests and many years of field experience.

Bulletin 985 is our fact book on Glasteel. For your copy, please write to the address indicated.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

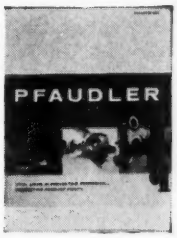
FLUIDICS AT WORK

Project Engineering, anyone? These absorber columns are part of an integrated chlorine dioxide generating plant that is not only Pfaudler equipped, but also Pfaudler engineered.

Which brings us to the services you can get from our Project Engineering group. This group functions as a temporary addition to your staff (or to your consulting firm) when you build or expand.

Pfaudler Project Engineering can help with any or all of the following: (1) Design of the system or plant, (2) Specification and selection of equipment, (3) Detailed plant layout, (4) Procurement and expediting, (5) Assistance in erection, (6) Start-up assistance and personnel training.

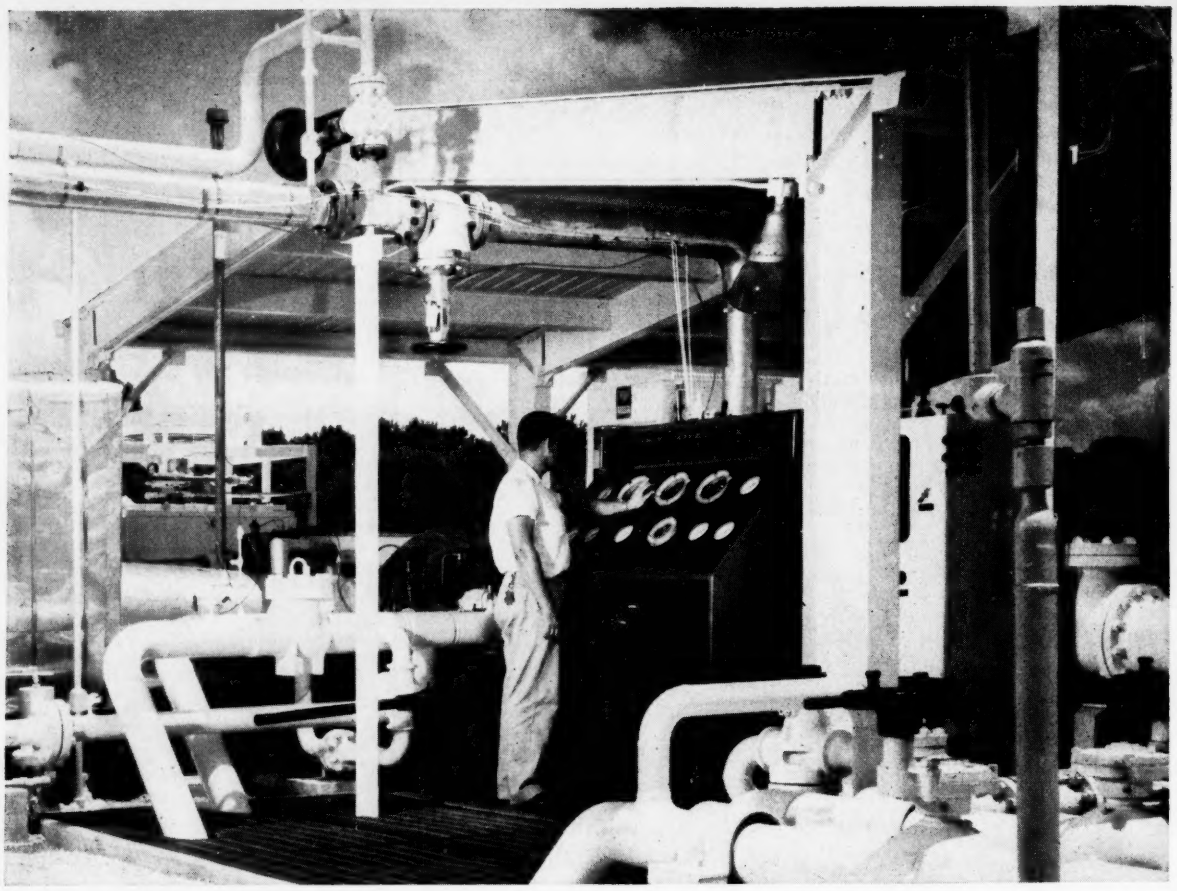
You provide the process and/or process data. We take it from there for such diverse fields as chlorine dioxide, polymerization, solvent recovery, esterification, detergents, resins, and recovery of metal finishing wastes. Inquiries invited.



Handbook for corrosion-resistant piping. Bulletin 987 details our line of Glasteel pipe, valves and fittings. In its 16 pages you'll find the specifications you need to eliminate corrosion as a problem when you transfer materials to and from process equipment. Ask for a copy.

Wiped Film Evaporator for heat-sensitive organics. At Jefferson Chemical Company, Inc., Austin, Texas, a 12″ I.D. Pfaudler® Wiped Film Evaporator distills heat-sensitive organics at an overhead rate of 500 lbs. per hour. The yield for these high-boiling organics works out to 42 lbs. per hr. per sq. ft. of heat transfer area. This evaporator, a unique wiped-surface evaporator, uses centrifugal force to hold four free-floating wipers in contact with the internal heated wall. This makes it well suited also to handling products that are highly viscous or low in thermal conductivity. Offer: Let us test your product in our Test Center. Or ask for a copy of Bulletin 991.

Address all inquiries to our Pfaudler Division, Dept. CE-101, Rochester 3, N. Y. In Canada, contact Pfaudler Permutit Canada Ltd., Toronto.



Trunkline uses Solar Gas Turbine compressor in pipeline station

Currently "on-line" at Trunkline Gas Company's Cypress, Texas, pipeline compressor station is an 1100 hp Solar *Saturn* gas turbine-driven centrifugal compressor set. In this application, it pumps up to 60 million cu ft of natural gas per day.

At Cypress, Trunkline is helping to pioneer a new concept: the use of a high-speed, turbine-driven centrifugal compressor in the low-volume range. Traditionally, reciprocating equipment has been the most practical in the range from 75 to 1000 inlet cu ft per minute at up to 1500 lbs pressure.

However, the availability of industrial high speed drivers, such as the Solar *Saturn* T-1000 gas turbine engine, has provided the impetus for Solar to design and build a line of efficient, long-life centrifugal compressors for this range.

The Trunkline installation is 1/10th the size of conventional compressor sets, costs an estimated 2/3rds as much to install and will run on a variety of fuels. At Cypress, for instance, the Solar compressor set runs on natural gas from the line. It would also run on gasoline, diesel fuel, kerosene or LPG fuels.

Another advantage of Solar compressor packages is the fact that a complete turbine-driven 1100 hp unit weighs less than 10,000 lbs and occupies under 300 cubic feet of space. It is easily portable.

Solar compressors are also ideal for field boosting. One *Saturn* turbine-powered set will deliver as high as 100 million cu ft per day. A unique modular concept of interchangeable compressor staging allows quick, easy field changes to accommodate changing pressure and flow requirements.

Solar's industrial turbomachinery is designed for rugged use. Solar turbines start instantly without warm up and are ideal for remote or unattended operation. Ranging from 50 to 1100 hp, they can deliver more power per pound than conventional engines for pumping, electric power generation, oil well servicing and other prime mover requirements.

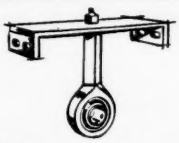
For more information about Solar turbomachinery, write Dept., Solar Aircraft Company, San Diego 12, California.

SOLAR

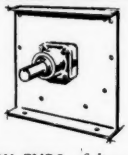
A subsidiary of International Harvester Company

YOU CALL THE TURN

LINK-BELT WILL MATCH ANY SCREW CONVEYOR NEED



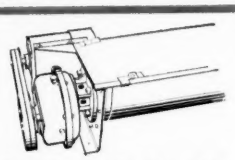
HANGERS have wide top bar with slotted bolt holes for easy assembly and alignment. Available with self-aligning ball bearing or with sleeve bearing in babbitt, hard iron, bronze or oil-impregnated wood.



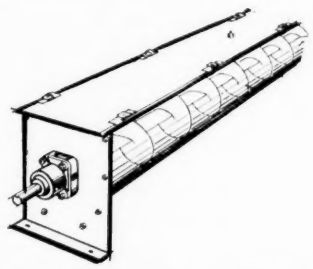
TROUGH ENDS of heavy steel plate are flanged at top and bottom. Furnished with babbitted, bronze or single or double ball bearing flange block with or without trough end seal. Blocks are interchangeable.

TROUGHS AND COVERS—Troughs are accurately formed and jig-assembled. Drop-bottom type facilitates cleaning. Covers can be *semi-flanged*, spring clamped type to facilitate removal.

QUIK-LINK CONVEYOR SCREW. For ease in removal of conveyor section without disturbing other components. Can be furnished on helicoid and sectional flight conveyors.



DRIVES—Link-Belt shaft-mounted speed reducers are simple, compact, rugged — designed for easy mounting on trough end plate. Moto-gears and gearmotors with roller chain drives can also be furnished.



TYPICAL LINE OF SCREW CONVEYOR—All components required to make up a complete screw conveyor are available from Link-Belt. One call, one order, one shipment for all your needs. And, you have the benefits of one-source responsibility.

SINGLE COMPONENT OR COMPLETE SYSTEM—STANDARD OR SPECIAL REQUIREMENTS! Yes, *you call the turn* . . . and you can count on Link-Belt to come up with the *right* answer.

Link-Belt offers conveyor screws in any suitable metal to meet temperature, corrosion, sanitation, abrasion and other requirements. Numerous *standard* types are available from stock in black and stainless steel. And if these can't solve your problem, our engineers will design an economical answer. We have furnished conveyor screws ranging from 1½ inches to over eight feet in diameter . . . with trough clearances as close as 1/32". What are your needs?.

Link-Belt offers an equally broad selection of all other components. All are built to rigid quality standards, made to fit together accurately to assure easy assembly . . . smooth, long-life operation.

You'll find Link-Belt screw conveyor components conveniently available from stock in your area. And expert engineering assistance may be obtained through any Link-Belt office. For details, contact your nearest Link-Belt office or authorized stock-carrying distributor. Ask for Book 2989.

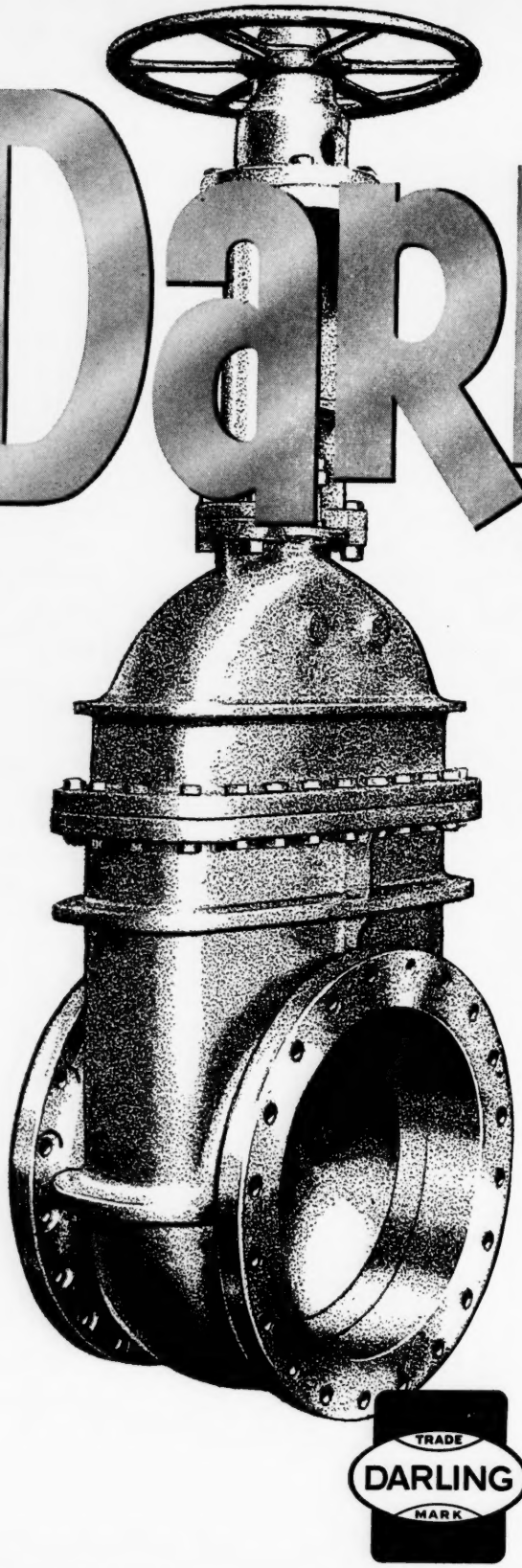
LINK-BELT

SCREW CONVEYORS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Warehouses in All Major Industrial Areas and District Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs; Switzerland, Geneva. Representatives Throughout the World. 15,742

YOU CAN DEPEND ON

Darling



Darling aluminum gate valves resist corrosive attack from chemicals such as hydrogen peroxide, ammonium nitrite, acetic acid and concentrated nitric acid. In such services *you can depend on Darling* aluminum gate valves to last longer, cut maintenance costs.

Darling metallurgists tested—then standardized—on aluminum alloys that provide maximum strength and corrosion resistance. Rigid quality control and precision assembly assure continuous ease of operation. The exclusive revolving double disc parallel seat feature means freedom from leakage and assures long service life.

Darling aluminum gate valves are available in sizes from ½″ through 24″. We will be glad to make recommendations.

SPECIAL ENGINEERING SERVICE. Darling engineers are ready to work with you in designing special valves to meet unusual service requirements. Write, wire or phone for prompt action.

TRADE DARLING MARK

DARLING VALVE & MANUFACTURING COMPANY

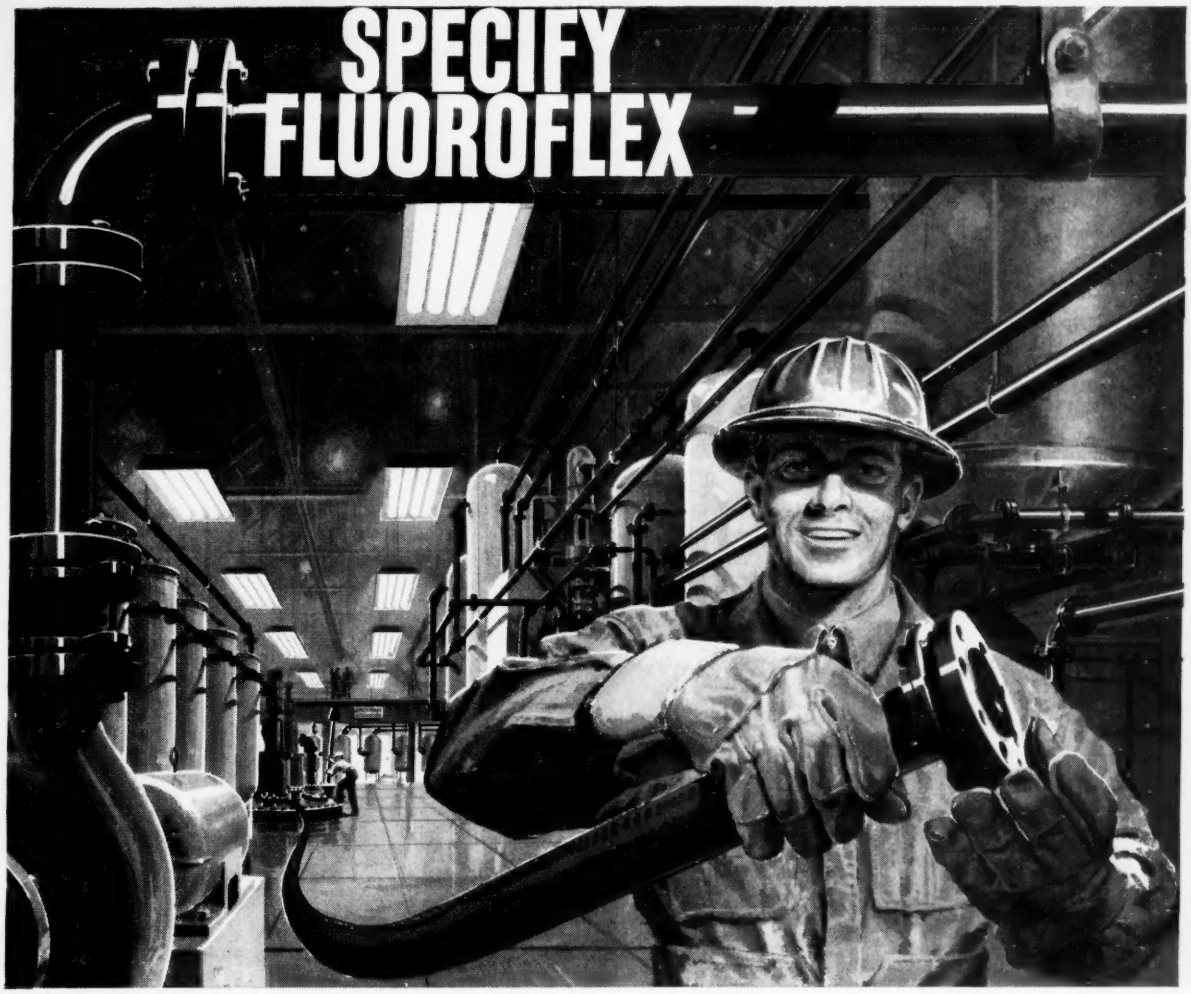
Williamsport 3, Pa.

Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario, Canada
Vannes Darling-France, 23 rue du Commandant Mouchotte, St. Mandé, France

GATE • BUTTERFLY • CHECK • SPECIAL VALVES • FIRE HYDRANTS

FOR MANUFACTURING ECONOMY

SPECIFY FLUOROFLEX



TO STOP CORROSION, DOWNTIME, AND PRODUCT LOSSES

Fluoroflex* has for years been providing superior performance in hundreds of plants here and abroad. Most chemical manufacturers now recognize that Fluoroflex systems lined with Teflon† provide *maximum savings* in production, erection, maintenance, and equipment replacement.

As a result leading engineering-construction firms now use Fluoroflex rigid piping systems and flexible components in new plant construction to stop corrosion or contamination and to reduce erection costs.

These systems are competitive with or cheaper than pressure piping of several high-nickel alloys on an *installed cost basis*. Also there is zero corrosion rate to all acids, chemicals, and solvents to 500°F., except for free fluorine and alkali metals at elevated temperatures.

Fluoroflex preflanged piping eliminates cutting, chamfering, cleaning, welding, scale, flux, weld spatter and annealing—minimizes the need for gaskets, hangers, supports, and anchors as required for non-metallic piping.

Resistoflex also manufactures a complete line of bellows and expansion joints, transfer hose, dip pipes, spargers, and thermowells.

If you have corrosive fluid-handling problems, SPECIFY FLUOROFLEX. Write to Resistoflex Corporation for detailed information today, or ask our local service engineer to call. Plants in ROSELAND, N. J., Anaheim, Calif., Dallas, Tex. Sales offices in major cities.

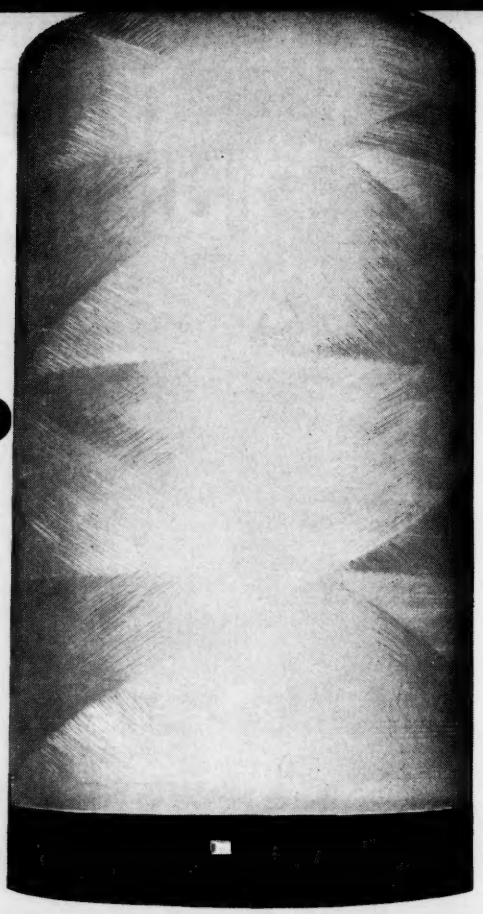
*Resistoflex T.M.
†DuPont T.M.

RESISTOFLEX
RELIABILITY

Complete systems for corrosive service

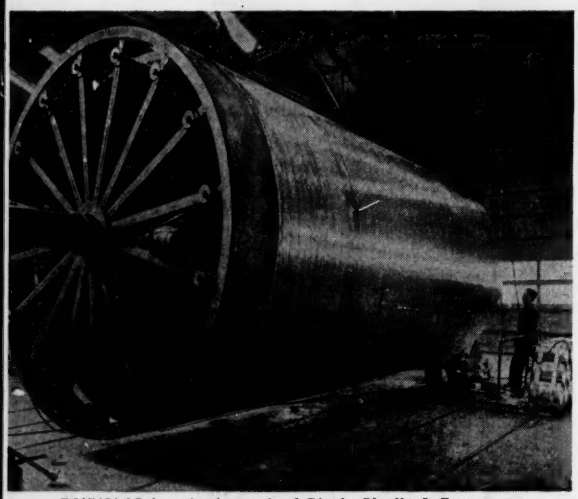
SEE US AT THE CHEMICAL INDUSTRIES SHOW, BOOTHS 893, 895, 897, N. Y. COLISEUM · NOV. 27 TO DEC. 1

from ACETIC ACID to XYLENE...



More than 200 corrosive chemical compounds can be handled safely and economically in

POXYGLAS™ TANKS



POXYGLAS is a trade mark of Black, Sivalls & Bryson, Inc.

If you are concerned with the storage or processing of corrosive materials, or product contamination—POXYGLAS Tanks are your likeliest answer.

Why? 3 to 4 times as strong as conventional reinforced plastic tanks. No maintenance costs for corrosion inspection or recoating. 1/6 the weight of comparable size welded steel tanks. POXYGLAS Tanks—produced by a machine operation—are constructed of continuous glass filaments impregnated with epoxy resin and wound under tension over a mandrel in a calculated, controlled pattern for maximum strength, consistent quality. Production manufacturing methods mean maximum corrosion protection at minimum cost.

STANDARD TANK SIZES:

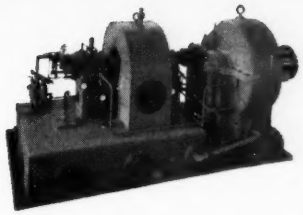
NOMINAL CAPACITY (gallons)	DIAMETER (feet)	HEIGHT (feet)
4,500	10	8
9,000	10	15
12,500	12	15
17,000	12	20

Want a POXYGLAS Corrosion-resistance Chart to see if your chemicals can be handled in POXYGLAS Tanks? Write to BS&B, Dept. 17-N10, P. O. 749, Ardmore, Okla.

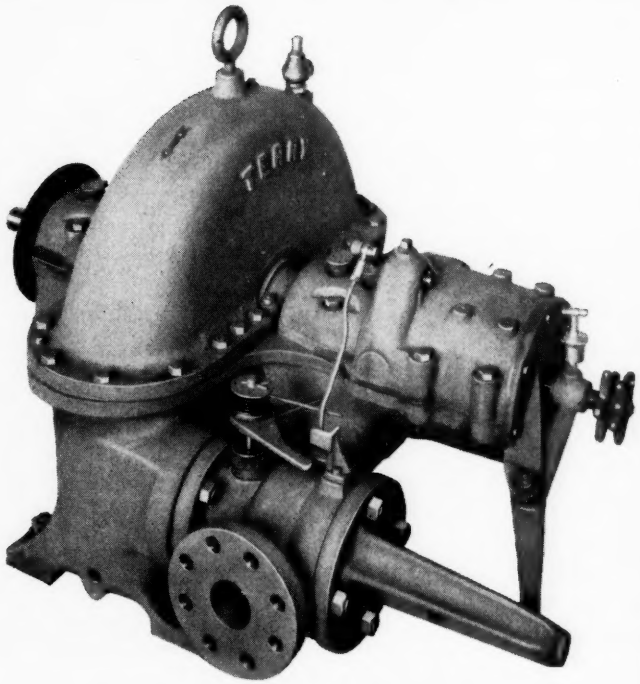
BS&B BLACK, SIVALLS & BRYSON

KANSAS CITY • ARDMORE • OKLAHOMA CITY • TULSA

There's a Terry solid-wheel turbine for any mechanical-drive requirement



Solid-wheel turbo-geared unit rated 600 hp, 4000/650 rpm.



Standard solid-wheel turbine with constant-speed mechanical-type governor and hand speed changer.

The completeness of the Terry line of solid-wheel turbines enables you to choose an *ideal* drive for any application . . . choose the specific features you want from a wide variety of designs.

Standard turbines are made in capacities up to 2,500 hp, with either cast-iron or cast-steel casings. The standard wheel is carbon steel. Where operation is to be at high speed or at high temperature, wheels of forged alloy steel are used. Vertical and geared turbines are also available.

And you can select from a range of governors, including: constant speed, either mechanical or oil relay, and variable speed, either direct acting or oil relay. Excess-pressure or constant-pressure pump governors are also available. When required, remote speed control can be furnished for variable-speed governors.

Tell us what your requirements are so we can send you full details of a turbine to meet your needs exactly. For general information, send for a copy of bulletin S-116.

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD 1, CONN.

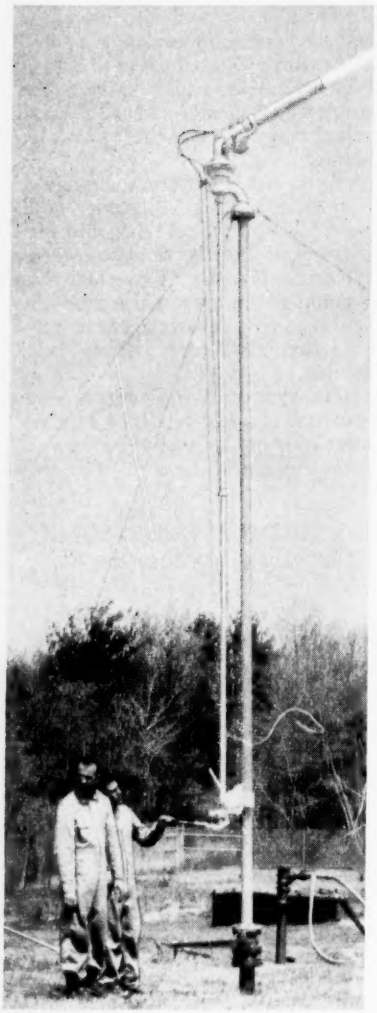
TERRY

Vertical turbines with the Terry solid wheel are available in capacities from 5 to 300 hp.

77-1218

Fight fires from any angle...
WITH ROCKWOOD SPECIALTY TURRET NOZZLES

Getting The Upper Hand...



Rockwood Extended Manual Control Turrets can be located 10 to 20 feet above a remote control station on the ground. Greater discharge range increases their fire fighting coverage. Higher extensions are engineered for special applications.

On the ground, on trucks, or towering over the flames, Rockwood Turret Nozzles are valuable fire fighting aids for use in refineries and chemical plants.

In fact, Rockwood makes the most complete line of specialty turret nozzles on the market. Every type is designed to fight fire four ways: with solid FOAM stream, FogFOAM, WaterFOG or solid water stream. And all are easily adjustable to meet changing fire conditions.

Throughout the country these Rockwood advancements are proving they can hit fires harder and faster. Find out how well they can protect your own plant. For an illustrated booklet on this complete line, write to Rockwood Sprinkler Company, Portable Fire Protection Department, 524 Harlow St., Worcester 5, Mass.

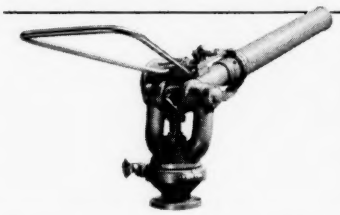
ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company
A Subsidiary of E. W. Bliss Company

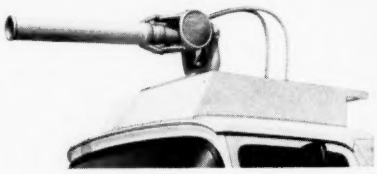
Engineers Water
...to cut fire losses

Distributors in all principal cities

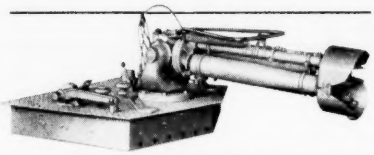
Fighting Fires Four Ways



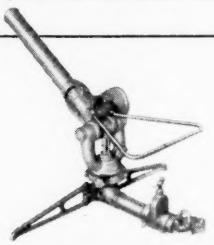
Rockwood Direct Manual Control Turrets give fire fighters "on deck" control from their cab roofs.



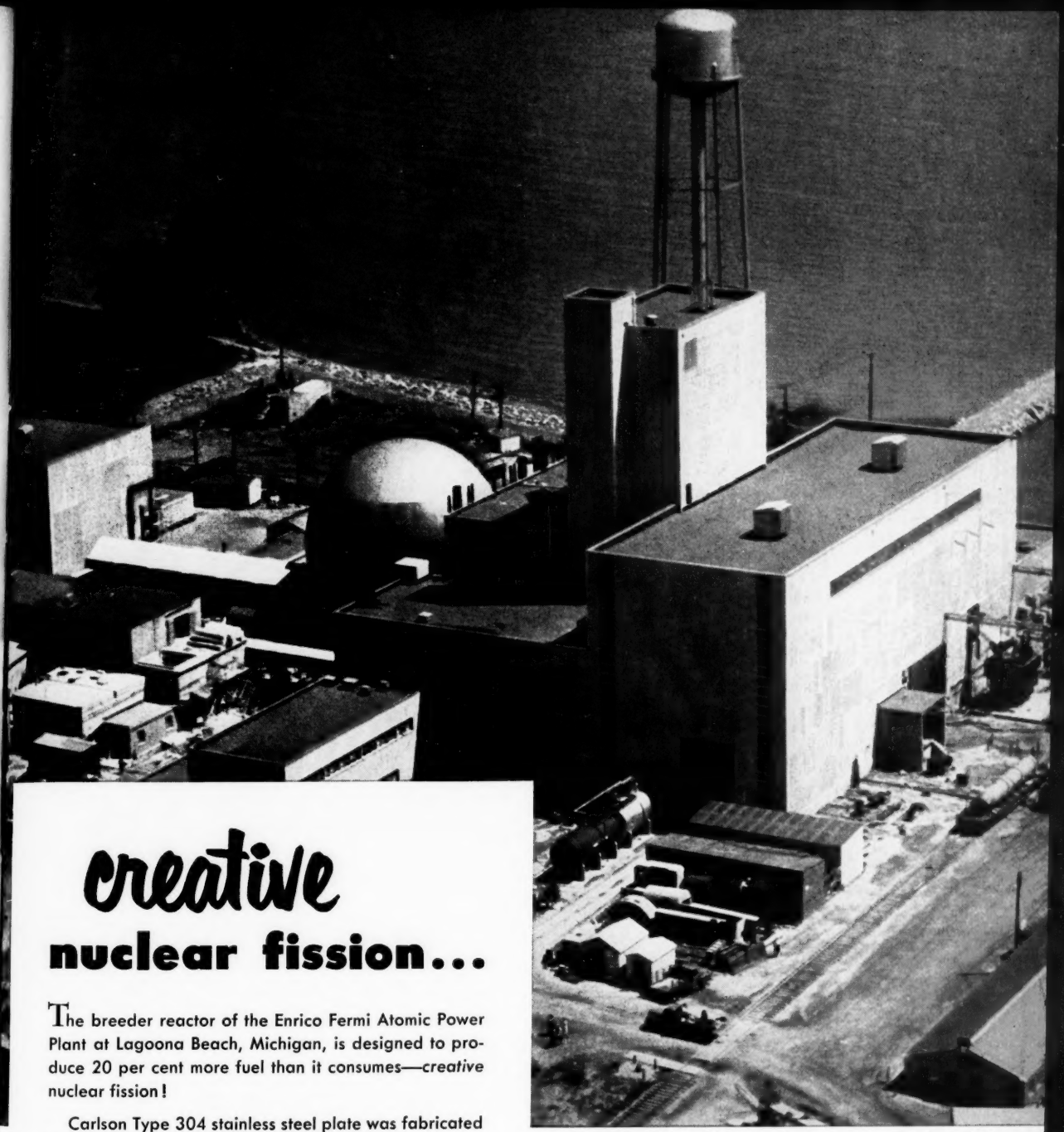
A Remote Manual Control Turret is easily handled by a man in the driver's seat. Ideal for fast action.



The Remote Hydraulic Control Type, single or dual model, is power controlled from within the cab. Widely used on crash rescue trucks.



The Portable Type goes off the truck and into action in seconds – wherever hose lines can be brought into action.



creative nuclear fission...

The breeder reactor of the Enrico Fermi Atomic Power Plant at Lagoona Beach, Michigan, is designed to produce 20 per cent more fuel than it consumes—*creative* nuclear fission!

Carlson Type 304 stainless steel plate was fabricated into the reactor vessel by Combustion Engineering, Inc. This plate must withstand the high temperatures and severely corrosive conditions associated with nuclear service.

Carlson specialists, working exclusively with stainless steel, maintain the precise quality standards essential in meeting critical service requirements. Whether you build nuclear power plants, missiles, or corrosion-resistant process equipment, you will find at Carlson a production and on-time delivery service you can trust. We will be glad to work with you on your projects. Write, wire or phone for detailed information.

If you would like a copy of our new booklet, "Producing Stainless Steels . . . Exclusively," please let us know.

Enrico Fermi Atomic Power Plant, Lagoona Beach, Michigan. Reactor section built, owned, and will be operated by Power Reactor Development Company. Conceptual design by Atomic Power Development Associates, Inc. Detail design and construction of reactor vessel by Combustion Engineering, Inc. The turbine-generating plant is built, owned, and will be operated by The Detroit Edison Company.

PHOTO COURTESY OF POWER REACTOR DEVELOPMENT COMPANY

G.O.CARLSON Inc.

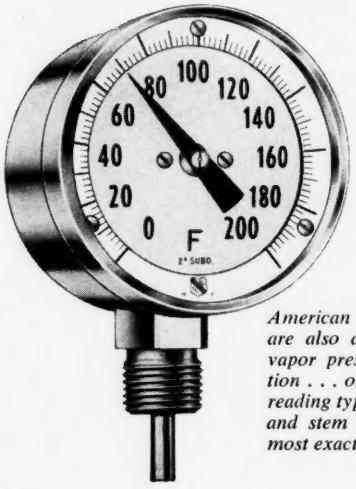
Producers of Stainless Steel

134 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

Plates • Plate Products • Heads • Rings • Circles • Flanges • Forgings • Bars and Sheets (No. 1 Finish

sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points



American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 155.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

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Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
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the only real drawout 2- to 5-kv controller...with a contactor you can get at, into, around...without tools

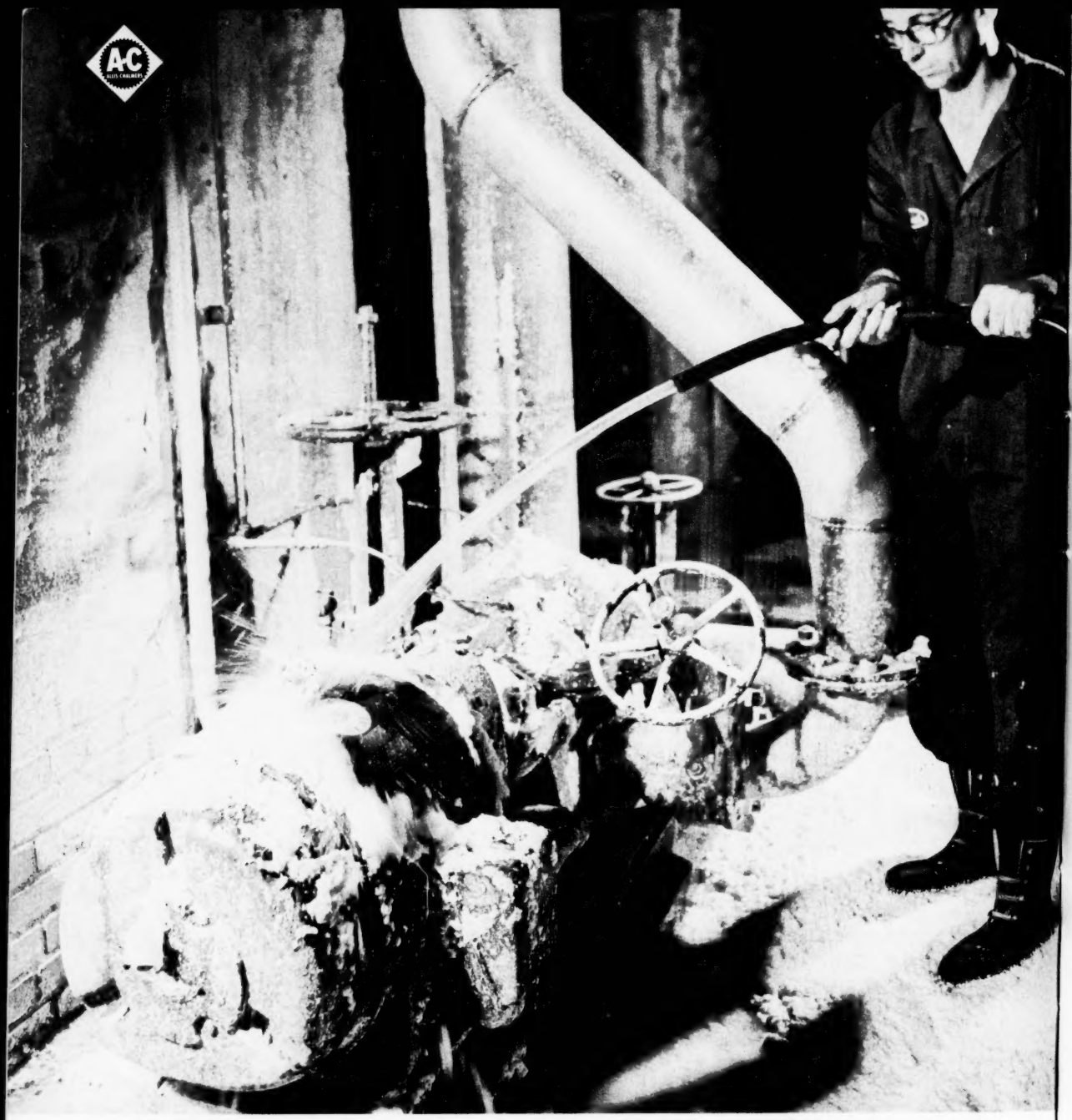
▲ This means no unbolting—no wires to unfasten. You rack the contactor to "disconnect position" with the door closed. Open door. Roll contactor carriage out. It's that simple, that quick . . . and safe. ● Inspection? Lift out arc chutes and barriers. Rotate pole pieces to fully expose contact structure. Fuses? Lift them out, too. No tools, all the way. ■ SPACEMAKER control. First dramatic new achievement in high-voltage motor control in more than a decade. To learn more about the many cost-cutting features, call your A-C distributor or representative. Or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

LET'S COMPARE THESE FEATURES

	SpaceMaker Controller	Controller "A"	Controller "B"
Two starters in 90" height	Yes	No	No
Drawout construction	Complete	Partial	No
Simultaneously disconnects all six main leads (line and load)	Yes	Line Only	Line Only
Automatic shutters isolate line	Yes	Yes	No
"No-tool" inspection of contacts	Yes	No	No
Track-resistant, flame-retardant insulation	Yes	No	No
Contactor construction	Double Break	Single Break	Single Break
Overload relays visible from outside	Yes	No	No

ALLIS-CHALMERS

A-1521



Open motor loves a shower

Despite constant exposure to a foamy pulp mixture . . . despite repeated "hosings" — this *Super-Seal* open motor never falters.

Its secret is *Poxeal* insulation. This Allis-Chalmers development shrugs off everything but work. *Everything* means water, dampness, dust, abrasives, corrosives, contaminants and weather.

In larger *Super-Seal* motors, *Silco-Flex* silicone rubber insulation offers similar benefits.

Besides all this, *Super-Seal* motors easily withstand sudden overloads. With their 15% service factor, they provide an extra safety margin not available in standard totally enclosed motors.

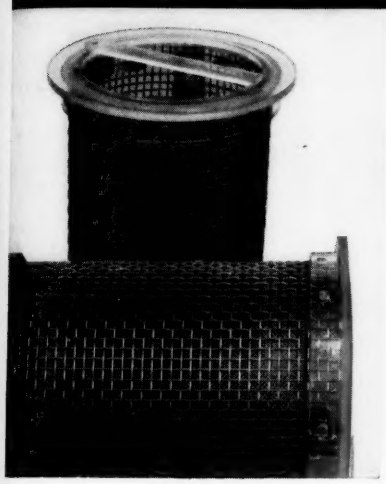
And they're available in a complete range of integral horsepower ratings.

For all the facts about our *Super-Seal* motors, call in your A-C representative or distributor. Or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin. A-1550

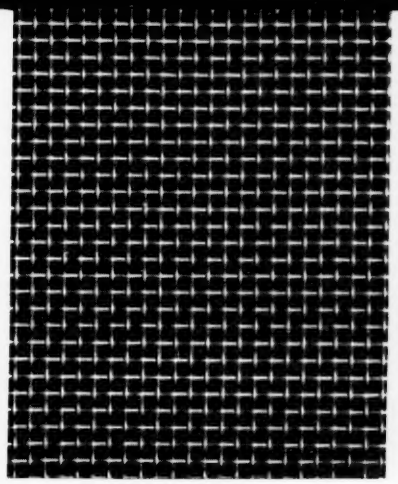
Super-Seal, Poxeal and Silco-Flex are Allis-Chalmers trademarks.

ALLIS-CHALMERS

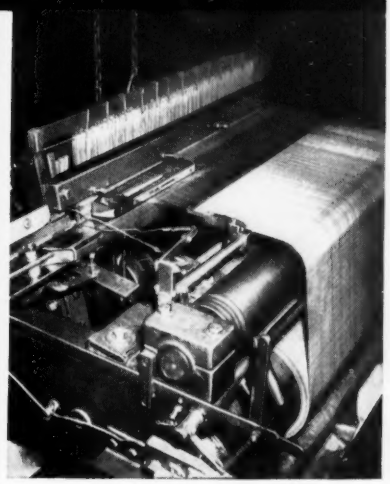
Need Wire Cloth in Special Metals? call *Cambridge*



HASTELLOY C*



SILVER



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Working with unusual metals or alloys—as well as with standard metals and alloys—is almost an everyday occurrence at Cambridge. For instance, not too long ago, we developed the first practical method of weaving titanium into wire cloth—with mesh counts far higher than had been expected by the customer. Platinum, lead, stainless steel, or bronze—whatever the metal or alloy used, Cambridge has the experience and facilities to produce wire cloth in any size or quantities to the closest tolerances.

If you require fabrications—of any shape or size—Cambridge has the craftsmen and know-how to fill even the most rigid specifications. Or, we'll draw up prints for your approval. There's a wire cloth expert near you—ready to discuss your needs and show you how to get what you want economically and on time. He's your Cambridge Field Engineer... and his name is listed in the Yellow Pages under "Wire Cloth." Or, write for our illustrated, 120-page catalog.

Refer to our technical data sheets in CHEMICAL ENGINEERING CATALOG, Page 185

VISIT US AT THE CHEMICAL EXPOSITION IN NEW YORK—BOOTH 1423

The Cambridge Wire Cloth Co.

DEPARTMENT G • CAMBRIDGE 102, MARYLAND

Manufacturers of Wire Cloth, Wire Cloth Fabrications, Metal-Mesh Conveyor Belts and Gripper® Metal-Mesh Slings.

*Reg. T.M. of Union Carbide Co.

B&W's NEW FITTINGS PLANT IS IN FULL OPERATION

NOW B&W CAN MATCH ALLOY PIPE AND FITTINGS TO END-USE SERVICE

B&W Welding Fittings manufacturing is completely integrated with the Division's own engineering, laboratory, steel-making and tube-making facilities. All are put to use to give you a job-matched alloy process piping system . . . welding fittings, flanges *and* pipe, quality-controlled from the melting of the steel to shipment of the finished product.

Integration plus first-hand knowledge of every phase of production enables B&W to furnish you the exact same alloys in fittings and flanges as well as pipe . . . a piping system matched to end-use service. For further information write for B&W bulletin FB78.

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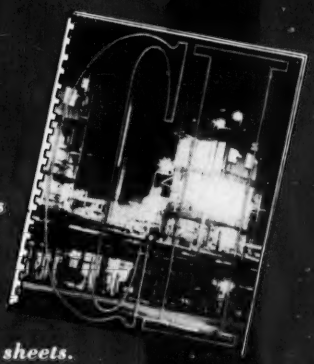
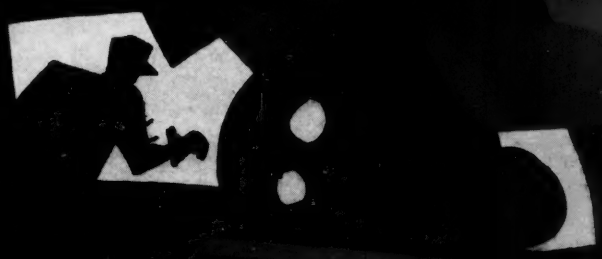
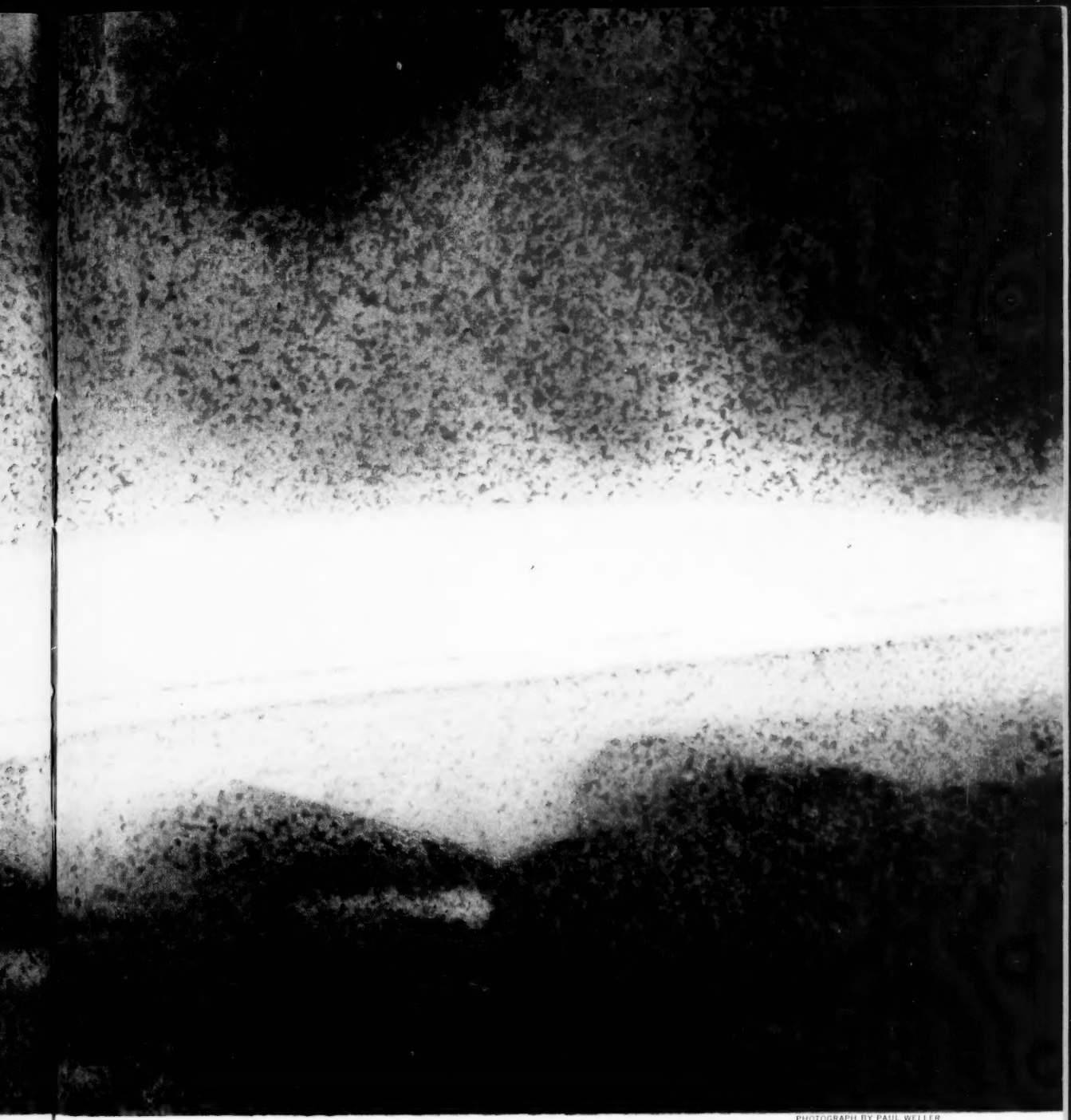


For more information on this proven C & I process, write today for a new brochure which contains comprehensive data and flow sheets.



Visit our exhibit (Booth 201) at the 28th Exposition of Chemical Industries.

THE EXTRA MEASURE



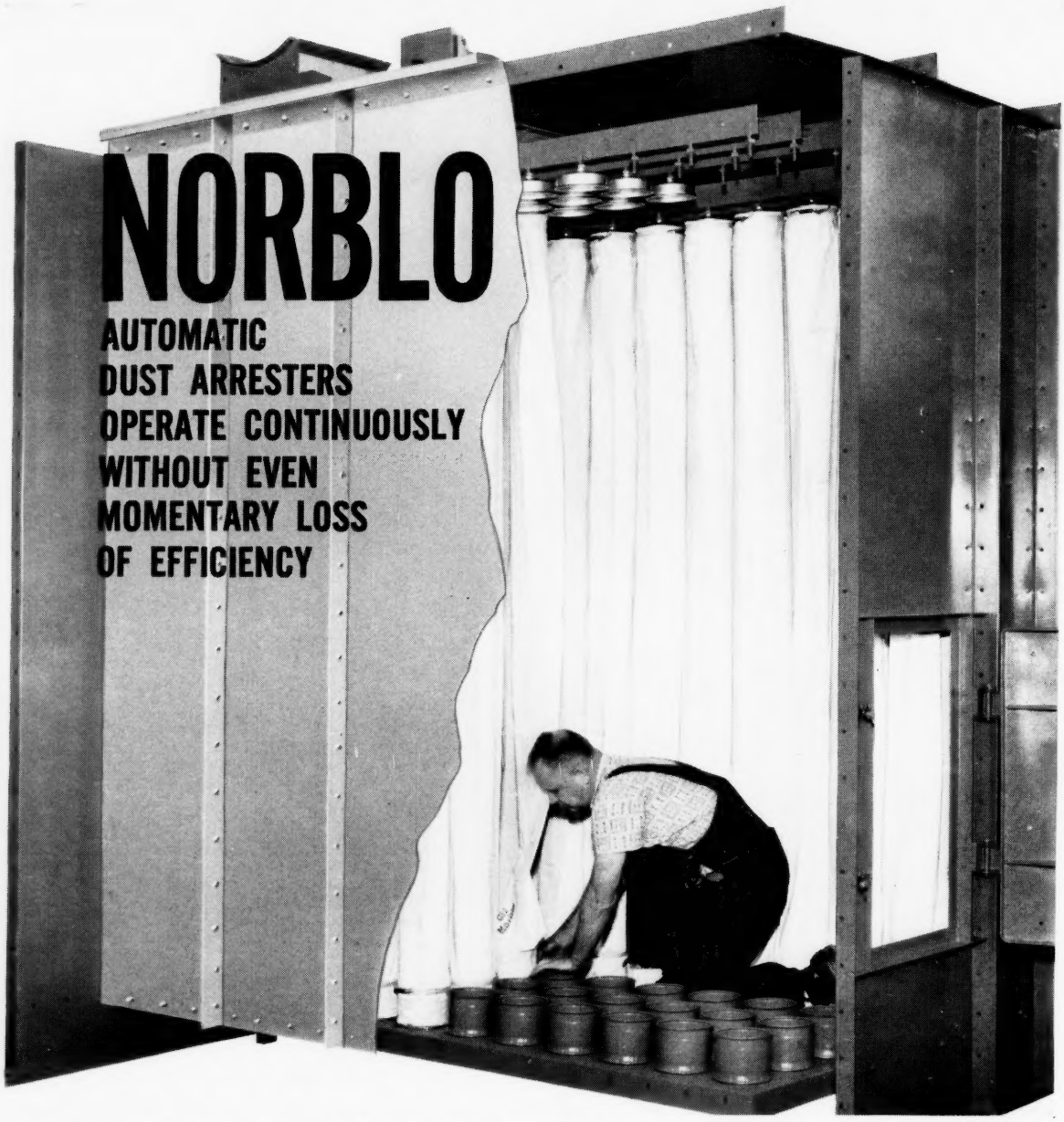
PHOTOGRAPH BY PAUL WELLER

Thoroughness. By a steelmaking specialist ■ On Lukens' 206-inch mill the world's largest steel plates are improved by the cross-rolling technique. Rolled lengthwise. Carefully measured. Turned and rolled sideways. Measured again. Lukens' cross-rolling procedure develops more uniform metallurgical properties. The extra measure of strength and quality essential to the fabricators of vital steel plate projects ■ Thoroughness is a Lukens habit, as well, in researching the best steels for difficult applications. Working with your engineers on problems of design and fabrication. Helping you select the best steel for the job from Lukens' complete line of carbon, alloy, armor and clad steel plates. Heads. Plate shapes ■ Thoroughness is one of many characteristics that make Lukens

LUKENS STEEL

THE SPECIALIST IN PLATE STEELS

Contact Manager, Application Engineering, 42-C Services Building, Coatesville, Pa.



Periodic cleaning, repair or replacement of bags, and minor maintenance can be accomplished while the collector remains in operation. One compartment, as shown above, can be isolated in the Norblo design, with all mechanical parts outside the gas stream. Continuous cyclic shaking, by compartment, allows operation without interruption. ■ This is why in modern plant operations you'll find an increasing preference for Norblo Automatic Bag Arresters. Where efficient production requires continuous operation more and more industries specify Norblo Dust Arresters. Over 80% of the cement industry relies on Norblo equipment for drying, grinding and finishing operations. ■ Buell-Norblo equipment can play an essential part in your process. Write for complete information on any type of dust collection problem. Buell Engineering Company, Inc., Dept. 12-J, 123 William Street, New York 38, New York. Northern Blower Division, 6408 Barberton Avenue, Cleveland, Ohio. Electric Precipitators · Cyclones · Bag Collectors · Combination Systems · Fans · Classifiers.

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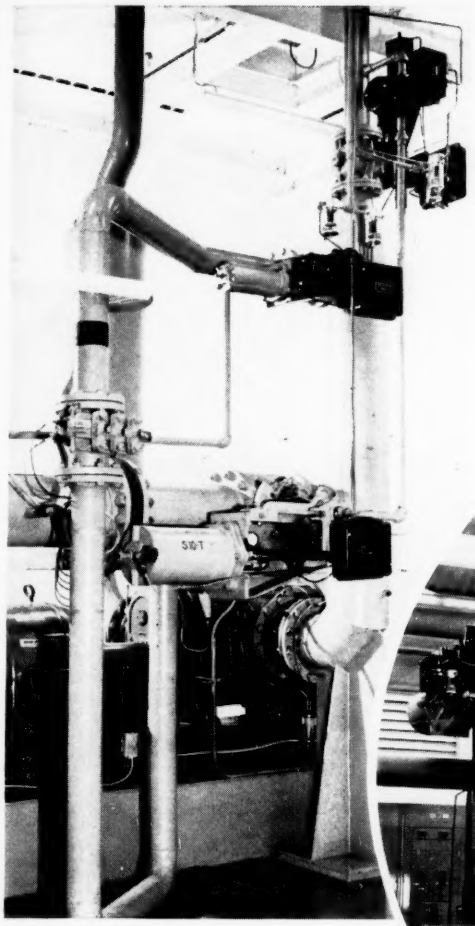
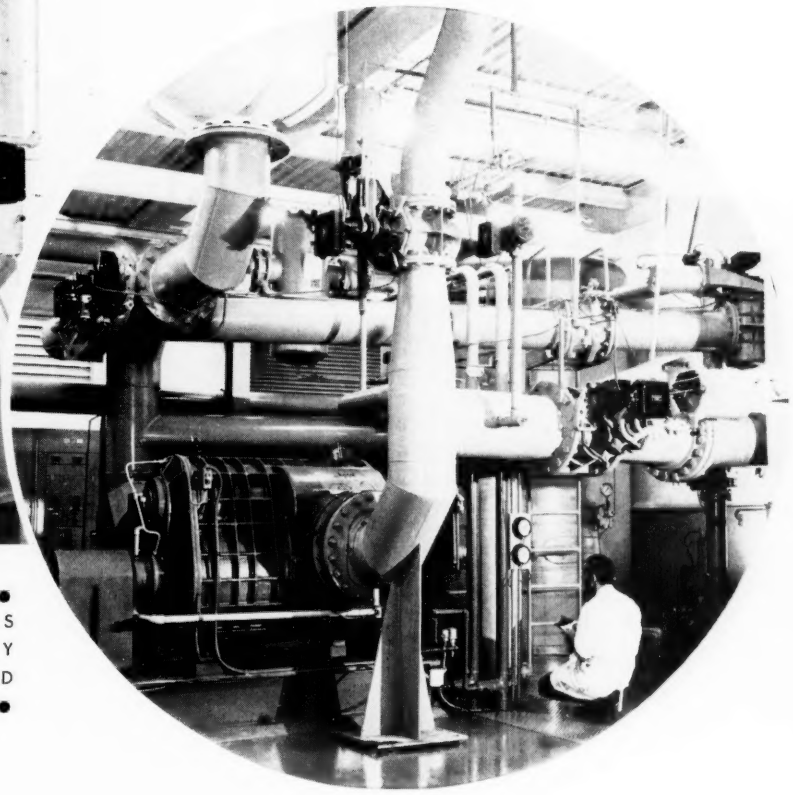
WHEN AIR MUST MOVE AT *Missile Speed*

DeZURIK VALVES CONTROL the AIRFLOW





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FLIGHT CONDITIONS simulating full rocket and aircraft experience . . . flows to 12,250 cfm of air at 5 psig, vacuums up to 24" Hg. . . . that's the job at this famed aero-test center in California. It's being done with DeZURIK CONTROL VALVES.

The control-system demanded simplicity, fast action, exit-pressure control to minimum tolerance, a myriad of flow combinations—plus absolute dependability, air-tight shut-off, certain safety, remote operation. DeZURIK CONTROL VALVES have provided all these features.

ELEVEN DeZurik "bleed and throttle" valves in sizes to 16" are involved on the primary and secondary compressor-exhausters. These instrumented valves have proved their total efficiency and trouble-free character in over 2 years of rigorous use in this complex space-age service.

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For example, in the plastics and synthetic fibres industries Sinclair petrochemicals are indispensable raw materials being used in the development of countless new and exciting products. Even when you add the new developments in paints, fertilizers, insecticides and detergents, you've only scratched the surface of profitable opportunities.

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Top news stories and what they mean to CPI technical decision-makers

Chementator

Unlined hole in ground holds liquefied gases without leakage

A radical approach to storage of liquefied gases has been successfully demonstrated in a pilot project by Conch International Methane, Ltd., London, and Constock-Pritchard Liquefaction Corp., Kansas City, Mo.

The technique is quite simple: a ring of earth is frozen, then a hole is scooped out of the middle of the ring. A vapor-tight aluminum roof is fitted to the hole as the final step.

Whimsically titled Operation Mudpie, the demonstration at Lake Charles, La., last month was called a complete success by the co-developers. Aimed primarily at storage of liquefied methane, the "frozen earth" process is claimed to be safer and more economical than conventional insulated surface storage tanks.

At the Lake Charles test site, the ground was first frozen by circulating refrigerant through a coil of pipes buried to a depth of 30 ft. (The diameter of the coil is greater than the intended diameter of the storage cavity.) When the frost line moved inward to the intended cavity-wall perimeter, excavation was started. The hole was dug 20 ft. deep and 20 ft. in dia., with a capacity of 850 bbl. The aluminum roof was then fastened to the ground.

The cold earthen wall, with no insulation and no liner, serves as the retaining tank wall. Project engineers report that there was no methane leakage and no ground swelling problem during the 30-day test period.

Turbine and jet-engine team fulfills hopes in year-long test

This October marks the first anniversary of an experiment that may inject a totally new factor into the business of prime movers. A jet-engine and turbine combination has successfully completed one year's service in gas compression.

Put through its paces at the Clementsville, Ky., station of the Columbia Gas System, the 10,500-hp. jet and turbine has demonstrated the claims made by its manufacturers, Cooper-Bessemer Corp. and Pratt & Whitney Aircraft (*Chem. Eng.*, Dec. 26, 1960, p. 42). Operating costs are within the predicted range of $21.70/hp./yr., and the jet has run 6,500 hr. without overhaul. It should reach the 8,000-hr. goal before the end of the year—the interval necessary between overhauls to hold down costs.

Heartened by the success of the venture, Cooper-Bessemer and Pratt & Whitney are moving rapidly to make five different jet-turbines, ranging from 340 to 15,000 hp., available to industry. Packaged units can be made for gas-transmission purposes that require only a small area and a single building, eliminate extensive yard piping, and operate remotely and unattended.

Other targets include service as prime movers for driving pumps, electric generators and compressors. In process applications, waste heat is available as an additional benefit.

Generator furnishes instant steam for short-term or emergency uses

Push a button—the steam plant starts. Push another button—steam stops. The unit that does this is not experimental, but is a commercially proved device that provides up to 150,000 lb./hr. of 200-psi. dry superheated steam. Built by Reaction Motors Div. of Thiokol Chemical Corp., it will be unveiled at the "Chem Show" in New York, Nov. 27 through Dec. 1.

Called the Hyprox steam generator, unit achieves instant operation by reacting hydrogen peroxide and hydrogen, rather than relying on the conventional—and slower—water-evaporation cycle. The single Hyprox assembly has four major parts: hydrogen peroxide injection and decomposition chamber; hydrogen preheating and injection section; hydrogen combustion chamber; water injection system.

CROUSE-HINDS

New Mark 9 CONDULET®

CONDUIT FITTINGS

Tough, thin die-cast walls and a new cover-opening design afford maximum space for easy, efficient wiring. No sharp edges to endanger hands or insulation in installation. Wiring is always readily accessible for repairs or alterations.

Feature for feature, the new Mark 9 line in copper-free, corrosion-resistant aluminum offers greater ease and economy in installation, plus dependable protection in an unusually wide range of types, sizes, and wiring devices. Write for Bulletin #2730 for information on Mark 9 and other Crouse-Hinds copper-free aluminum products. Or see your Crouse-Hinds distributor.

CROUSE-HINDS

REG. U.S. PAT. OFF.

MAIN OFFICE: SYRACUSE, N.Y. **FIELD OFFICES:** Albany, Atlanta, Baton Rouge, Birmingham, Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Corpus Christi, Dallas, Denver, Detroit, Houston, Indianapolis, Kansas City, Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Omaha, Philadelphia, Pittsburgh, Portland, Oregon, St. Louis, St. Paul, Salt Lake City, San Francisco, Seattle, Tampa, Tulsa, Washington. **RESIDENT REPRESENTATIVES:** Baltimore, Md., Meriden, Conn., Reading, Pa., Richmond, Va., Springfield, Mass. **FOREIGN AFFILIATES:** Crouse-Hinds Company of Canada, Ltd., Scarborough, Ont., Crouse-Hinds-Domex, S. A. de C. V. Mexico, D. F. **MANUFACTURING LICENSEE:** Peterco, Sao Paulo, Brazil

In operation, hydrogen peroxide feed decomposes to steam and oxygen over a silver-screen catalyst. These products indirectly preheat part of the hydrogen feed, which then mixes with the decomposed peroxide. When mixture reaches the main combustion chamber, it burns to form superheated steam. Cooling water, after flowing in a jacket around the combustion chamber, is combined with the exit gases to produce additional steam.

Because of feed costs, steam from a Hyprox generator costs about 14.5¢/lb. But the unit has a much lower initial cost than standard water-tube boilers, and its compactness, portability and quick-starting features make it a candidate for use as an emergency steam source for peak-load operation, pilot-plant service and high-vacuum applications in which the steam operates an ejector.

Unit can be built for almost any capacity or steam pressure. Initial cost is around $100,000 for a 150,000-lb./hr. unit.

The device is already being used to operate vacuum-ejection units for cryogenic subcooling of liquid hydrogen and for high-altitude simulators.

Du Pont is doubling nylon tire-cord capacity to 100 million lb./yr. at its Richmond, Va., plant. New production will be Type 714 nylon, claimed to have 25% better fatigue resistance than other nylon cords.

Foam makers can get "insurance policy" with polyether purchases

Of the estimated 70 million lb. of polyethers that will go into urethane foams this year, use of more than 80% is covered by U. S. Patent 2,866,774—owned by General Tire & Rubber Co. However, this patent is being contested by Mobay Chemical, and the industry has been anxiously awaiting the outcome because it means most foam producers will have to take a license from the winner.

Now, Union Carbide Chemical, which supplies at least half the polyethers used in urethane foams, has eased the suspense somewhat. Without waiting for the court decision, Carbide has purchased patent rights from General Tire, along with the right to grant sublicenses to Carbide customers. The royalty-free sublicenses will grant immunity from infringement suits should the courts uphold General's patent.

Carbide probably decided to take this precautionary step because a General Tire triumph would have more serious consequences than a win by Mobay. General Tire, unlike Mobay, produces polyurethanes but not the raw materials (Mobay makes no foams, only the diisocyanates). Thus, General would have more to gain by pressing its patent claims on competing foam producers than would Mobay, which would only be challenging its own customers.

Carbide's new "insurance policy" thus protects its polyether markets from the major disruption that might result from a General Tire court victory. And it also gives Carbide a powerful sales tool in marketing its polyethers.

The patent in question was originally developed by C. C. Price while at Notre Dame University; exclusive rights were subsequently sold to General Tire. Patent covers urethane products made from polyethers via one-shot foaming systems.

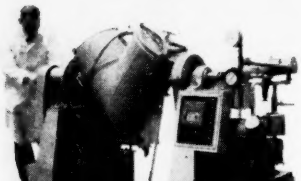
First fluorocarbon monofilaments slated for commercial production

Du Pont's Teflon FEP (fluorinated ethylene-propylene), the second fluorocarbon fiber to reach commercial stage, will be produced in a 100,000-lb./yr. monofilament unit at Richmond, Va., starting this December. Like its predecessor, Teflon TFE (tetrafluoroethylene) multifilament, the new FEP fiber aims to replace metals in filter media and tower packing.

Eventually, Du Pont hopes fluorocarbon fibers will take a substantial bite out of the 40,000-ton/yr. market for stainless steel wire. Teflon fibers are only one-fourth as heavy as stainless for equal lengths and gage, and Teflon's service life is not limited by corrosive conditions as is stainless. Teflon fibers are chemically inert and retain their strength even after prolonged exposure at temperatures up to 400-500 F. and down to -400 F. They are completely mildew-resistant and are not degraded by ultraviolet light.

However, stainless wire now costs only about $2/lb., compared with FEP monofilament at $20-45/lb. and $14-125 for TFE multifilament. Thus,

(Continued on page 50)



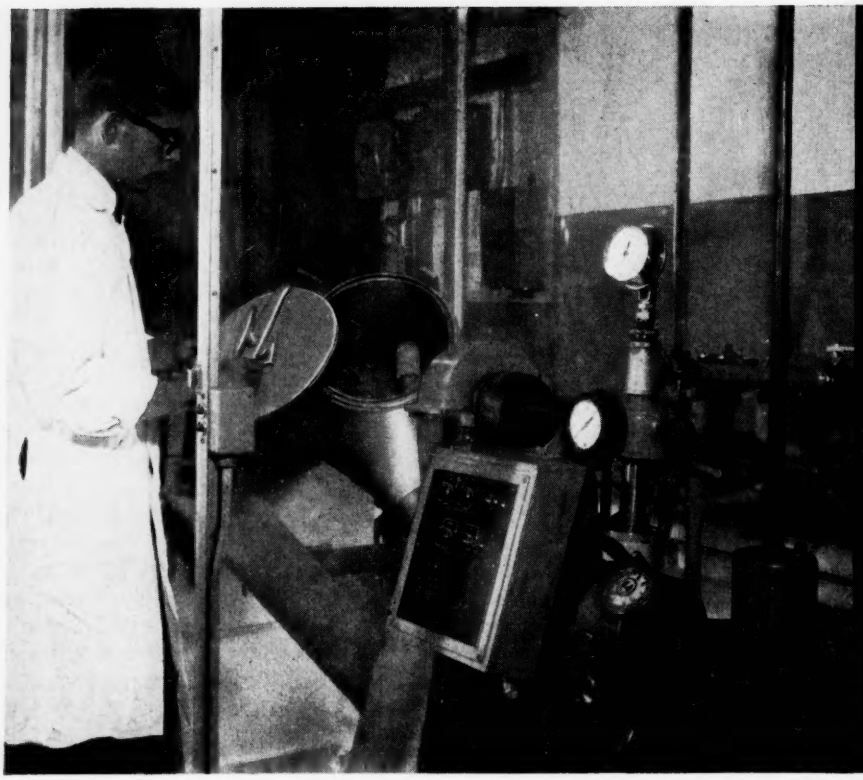
P-K SOLIDS PROCESSOR* SIMPLIFIES WESTINGHOUSE LAMP-MAKING OPERATIONS

Eliminates outmoded mixing, oven and screening steps • Reduces materials handling • Improves thoria quality

A ten cu. ft. P-K Solids Processor has consolidated a multi-step processing operation into a single unit operation – and improved product quality – for the Westinghouse Lamp Division, Bloomfield, N. J.

The pre-packaged unit blends, disperses liquids, and vacuum dries in simple sequence in the production of thoria, a material which adds strength and toughness to the tungsten wire used as lamp filament. Outmoded mixing, tray drying and screening

*patented



IN R & D — A one cu. ft. model is used in the development of experimental materials. Unit, purchased as a result of a pre-test at P-K's Pre-Test Laboratory, was used to work out thoria process now in use. Its unique flexibility, drying range, plus accurate instrumentation, in a complete package, make it an ideal research tool.

IN PRODUCTION — First, unit preblends 400 kilograms of tungsten oxide for five minutes. Then, a thorium nitrate solution (10% of total charge) is added. Full vacuum is pulled and steam-heated jacket dries material in five hours.

PACKAGED P-K SOLIDS PROCESSOR performs up to 10 operations in simple sequence and in combinations:

1. Precision gentle blending. 2. Intensive blending. 3. Liquid-solids blending. 4. Granulation of solids. 5. Vacuum drying of solids. 6. Coating of solids. 7. Heat sterilization of solids. 8. Gas sterilization of solids. 9. Chemical reaction of solids. 10. Heating or cooling of solids.

Installation of totally packaged unit — including all wiring and instrumentation — requires only electric and water connections.

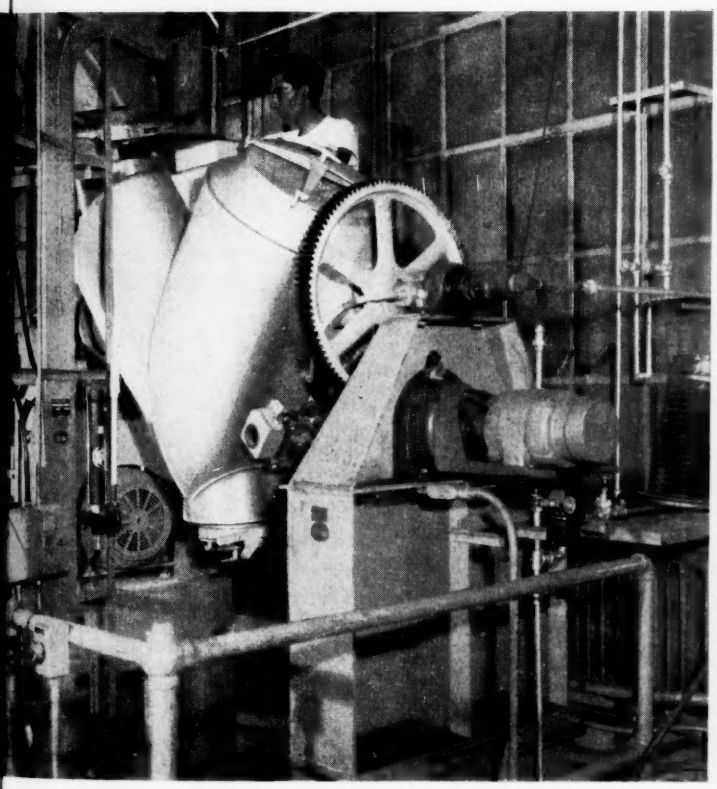
equipment previously used – and the accompanying materials handling steps – have been eliminated, and a critical toxic dust problem has been solved.

Moreover, according to Russell H. Atkinson, Manager of Lamps Parts Engineering, "Substantial quality improvement resulting in increased lamp life has been realized through the superior blending, liquid dispersion and drying of this three-in-one packaged Solids Processor."

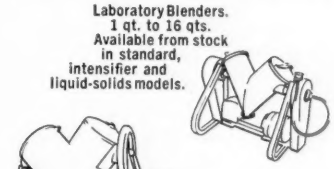
PRE-TEST FACILITIES. Westinghouse pre-tested these economies. Why not explore the possibilities of simplifying your own solids processing operations at the P-K Pre-Test Laboratory. You'll find pilot models of standard, intensifier, and liquid-solids "Twin-Shell" blenders; packaged tumble dryers; ribbon and double-cone blenders; as well as the new Solids Processor.

Here, under your supervision, skilled engineers will test-blend your materials. They'll point out product improvements and process modernization . . . introduce you to new concepts in solids processing . . . predict potential economies in time, space, labor and equipment.

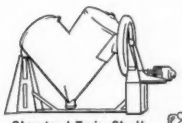
TO MAKE ARRANGEMENTS, write or phone George Sweitzer at Stroudsburg. Call direct by dialing 717–HAmilton 1-7500. He'll supply you with all the necessary information – dates, amount of material required, shipping and travel details.



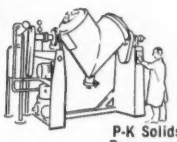
P-K PROCESSING EQUIPMENT



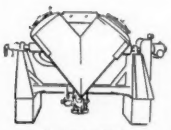
Laboratory Blenders. 1 qt. to 16 qts. Available from stock in standard, intensifier and liquid-solids models.



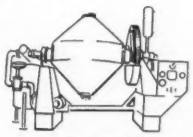
Standard Twin Shell Production Blenders. 1 cu. ft. to 4,000 cu. ft.



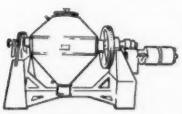
P-K Solids Processors. 1 cu. ft. to 50 cu. ft.



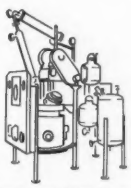
P-K Liquid-Solids Blenders. 1 cu. ft. to 50 cu. ft.



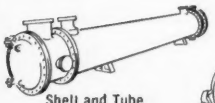
Packaged Vacuum Tumble Dryers. 1 cu. ft. to 300 cu. ft.



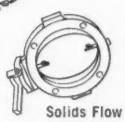
Standard Cone Blenders. 1 cu. ft. to 4,000 cu. ft.



Packaged Pilot Plants



Shell and Tube Heat Exchangers



Solids Flow Valve

REPORT ON SOLID-SOLID BLENDING. 23-page color article from Chemical Engineering discusses blending theory, practice, equipment and economies. Available upon request. Also ask for new P-K process equipment catalog No. 17-P. Heat Exchanger Manual No. 700-A, available upon company letterhead request.

Patterson Kelley

CHEMICAL AND PROCESS EQUIPMENT DIVISION
1210 BURSON STREET, EAST STROUDSBURG, PA.

current targets for the fibers are applications now served by high-priced metals like Hastelloy, titanium and tantalum. When it can bring price down to $8/lb., Du Pont expects Teflon fibers to be fully competitive with stainless wire.

Distinctions between markets for the two fluorocarbon fibers are based on differences in their structure: the TFE multifilament lends itself to fine-pored media such as fabrics and needle-punched felts; the FEP monofilament is more suited for larger-pored screening, e.g., filter fabric where back-washing is needed, or where stiffness is a prerequisite to the support of a precoat.

One commercial use for FEP fibers is in de-entrainment service; Otto H. York Co. is already in production of demisters using these monofilaments.

A new route to synthetic glycerin has been piloted by Pittsburgh Plate Glass, but no details are yet available. Process will first be used in Italy, where the firm has a joint venture with Rumianca, S.p.A. However, PPG has no immediate plans to manufacture glycerin in the U. S.

Exotic pulping processes get "show me" response from paper industry

Pulp and paper experts are adopting a skeptical attitude toward the new hydrotropic and semi-hydrotropic pulping processes developed by Dr. Ralph H. McKee of Columbia University.

In a recent announcement, McKee pointed out that his processes would: consume only 1% of the water now used in pulping, eliminate stream and atmosphere pollution, permit re-use of chemicals, produce more paper per cord of wood at lower costs than older processes.

Observers say, however, that such processes have been known for some 20-30 years, and though the method is feasible, it hasn't and won't draw widespread attention from paper makers.

They cite three reasons to support this opinion: (1) pulp produced by this method isn't superior to that made by existing plants; (2) economically, hydrotropic pulping will have a tough time competing with established processes that use cheap, easy-to-handle chemicals; (3) the proposed lignin filtering step will be troublesome.

In McKee's process, a 30% pulping solution of sodium xylenesulfonate dissolves lignin from hard- or softwood chips, which are then filtered off and washed. Remaining liquid is first diluted with water to precipitate lignin, then filtered and evaporated back to the original concentration for re-use.

Another process being talked about is catalytic pulping, a hardwood processing method devised by consultant Francis H. Snyder, New Milford, Conn. This process uses a catalyst to break lignin into small phenolic-type compounds, which can then be easily dissolved by a cold caustic solution.

Besides having an extremely low digestion time (20-40 sec. for destruction of lignin), the process is claimed to have economic advantages over other hardwood processes (*Chementator*, Aug. 24, 1959, p. 55). Snyder estimates that pulp in slurry form can be made for $60-70/ton.

New thinking called for in synthetic-fiber technology

Synthetic fibers must achieve significant new advances to make any further penetration of the textile market.

This was the opinion of H. F. Mark of the Polytechnic Institute of Brooklyn and S. M. Atlas of Bronx Community College in a paper presented before the Conference on New Trends in Chemistry, in Chicago last month. The conference was sponsored by Armour Research Foundation and CHEMICAL ENGINEERING.

According to Atlas, who delivered the paper, the textile industry is just about saturated with synthetics. Any new one is going to have to offer textile makers either significantly improved properties or else duplicate present properties at lower prices—from 65-80¢/lb.

Fibers of nylon 6 offer a good chance of meeting the lower price requirement, noted Atlas. Simpler processes for producing the nylon-6 monomer (caprolactam) from cyclohexane prompt this optimism. Du Pont, for example, has a new caprolactam plant at Orange, Tex., that nitrates cyclohexane over a heterometaphosphoric acid catalyst. Resulting nitrocyclohexane is then converted into the lactam.

Assuming benzene costs 5¢/lb., cyclohexane

secretary's desk?

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can be valued at 8¢/lb., nitrocyclohexane at 12¢/lb. Du Pont should thus be able to make caprolactam for less than 25¢/lb. and the polymer for about 30¢, said Atlas. Assuming 40¢/lb. for converting polymer to a fiber (via melt-spinning), it should be possible to produce nylon-6 staple for 70¢/lb.

The other main possibility for producing low-cost textile fibers is polypropylene. Atlas notes that two main problems are holding it back: loss of tensile strength at elevated temperatures and inability to accept dyes readily.

Intense research on additives and radiation crosslinking has succeeded in raising polypropylene's softening point up to about 430 F. A third avenue being investigated is grafting of acrylic acid or acrylonitrile to polypropylene, increasing the softening point to 390 F.

To increase dye acceptance, blowing agents are being used experimentally to create a small degree of foaming as the fiber leaves the spinneret. During drawing and stretching, the bubbles form into tiny interconnecting cracks that spectacularly increase the fibers' ability to accept dyestuffs from aqueous baths.

Vulcanizable polyethylene gets set to push into wire and cable coating

Consumption of chemically cross-linked polyethylene—in its infancy today—is expected to reach 14 million lb./yr. in wire and cable coating alone by 1966.

In the past three or four months, three of the half dozen major wire and cable producers—General Electric, Anaconda and Simplex—have started using the new coating commercially. And Union Carbide Plastics has begun to market commercial quantities of polyethylene resin that is chemically compounded for cross-linking.

Chemically cross-linked polyethylene boasts the same set of improved properties as does irradiated material. Cross-linking superimposes many of the desirable properties of elastomers or thermosetting materials (e.g., resistance to melting) on the excellent electrical properties of natural polyethylene. But backers of chemical cross-linking believe it has much broader commercial potential because, they claim, irradiation is expensive and awkward to use, does not cross-link more than the surfaces of the plastic. To avoid confusion between products of the two techniques, Carbide refers to the chemically cross-linked variety as vulcanizable PE.

Initial targets for the vulcanizable resin are replacement of neoprene on line wire and replacement of butyl rubber on power cables. Currently about 25 million lb./yr. of neoprene and 4 million lb. of butyl are absorbed by these uses.

Growing markets for vulcanizable PE are also increasing the demand for organic peroxides. Dicumyl peroxide, used as the cross-linking agent at a rate of three parts per 100 parts of resin, is the most popular choice right now.

Cryolite chemistry brings aluminum maker into fluorocarbon production

Moving further into the chemical business, Kaiser Aluminum & Chemical Corp. has announced plans to erect a $6-million hydrogen fluoride and fluorocarbon plant at Gramercy, La. For its fluorocarbon line, Kaiser intends to market a full range of fluorinated refrigerants, propellants and blowing agents.

The company's move is an extension of its experience in fluorine chemistry, mainly synthetic cryolite (Na_3AlF_6) and aluminum fluoride, both used in aluminum smelting. Nevertheless, the firm's entry has surprised many observers because there is an overcapacity in both hydrogen fluoride and fluorocarbons.

Of the estimated 125,000 tons/yr. of HF consumed in the U. S., about 110,000 tons is produced captively. So, the merchant market, already served by such producers as Allied, Du Pont, Pennsalt and Stauffer, is relatively small. Adding to capacity, Dixon Chemical will be coming on stream late this year with a 10,000-ton/yr. plant at Paulsboro, N. J.

The fluorocarbon picture is similar. Consumption is now estimated to be around 275 million lb./yr., while capacity is about 500 million lb./yr.

The other two major aluminum producers—Reynolds Metals and Aluminum Co. of America—also have the same background in fluorine chemistry but say they have no plans at this time to follow Kaiser's move.

In fact, Alcoa is going in the opposite direction. It has sold its East St. Louis inorganic fluorides plant to Stauffer Chemical, effective Nov. 1. Primary reason for pulling out of fluoride chemicals: low profitability.

For More Industry & Economic News . . . p. 54

Excitement... about a new chemical fresh from Research and Development!

B&A® SULFAMIDE

Recently, one of our ads went on a "fishing expedition" to explore possible uses for a number of new chemicals. *Among them was B&A Sulfamide.* So much interest was expressed in Sulfamide that we are taking this opportunity to tell you more about it.

B&A Sulfamide is similar to urea in many of its reactions, except that it is more acidic, and can act as a dibasic acid. Here are twelve properties and reactions of this interesting new chemical. Do they give you some ideas of your own?

Nitration

$NH_2SO_2NH_2 + HNO_3 \longrightarrow NH_2SO_2NHNO_2 + H_2O$

Chlorination

$NH_2SO_2NH_2 + HOCl \longrightarrow NH_2SO_2NHCl + H_2O$

Salt Formation

$NH_2SO_2NH_2 + 2NaOH \longrightarrow NaNHSO_2NHNa + 2H_2O$

Various mono- and di-metallic salts have been made.

Heat

$NH_2SO_2NH_2 \longrightarrow NH_2(SO_2NH)_xSO_2NH_2 + (SO_2NH)_3 + NH_3$

Hydrolysis

$NH_2SO_2NH_2 + H_2O \longrightarrow NH_2SO_3NH_4 \xrightarrow{H_2O} (NH_4)_2SO_4$

Sulfamide is stable in dilute acid or alkaline solution.

PCl_5

$NH_2SO_2NH_2 + 2PCl_5 \longrightarrow SO_2(N{:}PCl_3)_2 + 4HCl$

Alcohols

$NH_2SO_2NH_2 + 2ROH \longrightarrow R_2O + NH_2SO_3NH_4$

Sulfamide is a strong dehydrating agent under some conditions.

Organic Acids

$NH_2SO_2NH_2 + RCOOH \xrightarrow{Pyridine} RCONH_2 + ?$

Amines

$NH_2SO_2NH_2 + RNH_2 \longrightarrow NH_2SO_2NHR \xrightarrow{RNH_2} RNHSO_2NHR + NH_3$

Primary and some secondary amines react thus.

Acylating Agents

$NH_2SO_2NH_2 + RCOCl \longrightarrow RCONHSO_2NH_2 \xrightarrow{RCOCl} RCONHSO_2NHCOR + HCl$

Acid anhydrides react similarly.

Aldehydes

$NH_2SO_2NH_2 + C_6H_5CHO \longrightarrow NH_2SO_2N{:}CHC_6H_5 + H_2O$

Other aldehydes may form methylols or resins, depending on conditions.

Isocyanates

$NH_2SO_2NH_2 + RNCO \xrightarrow{Base} NH_2SO_2NHCONHR$

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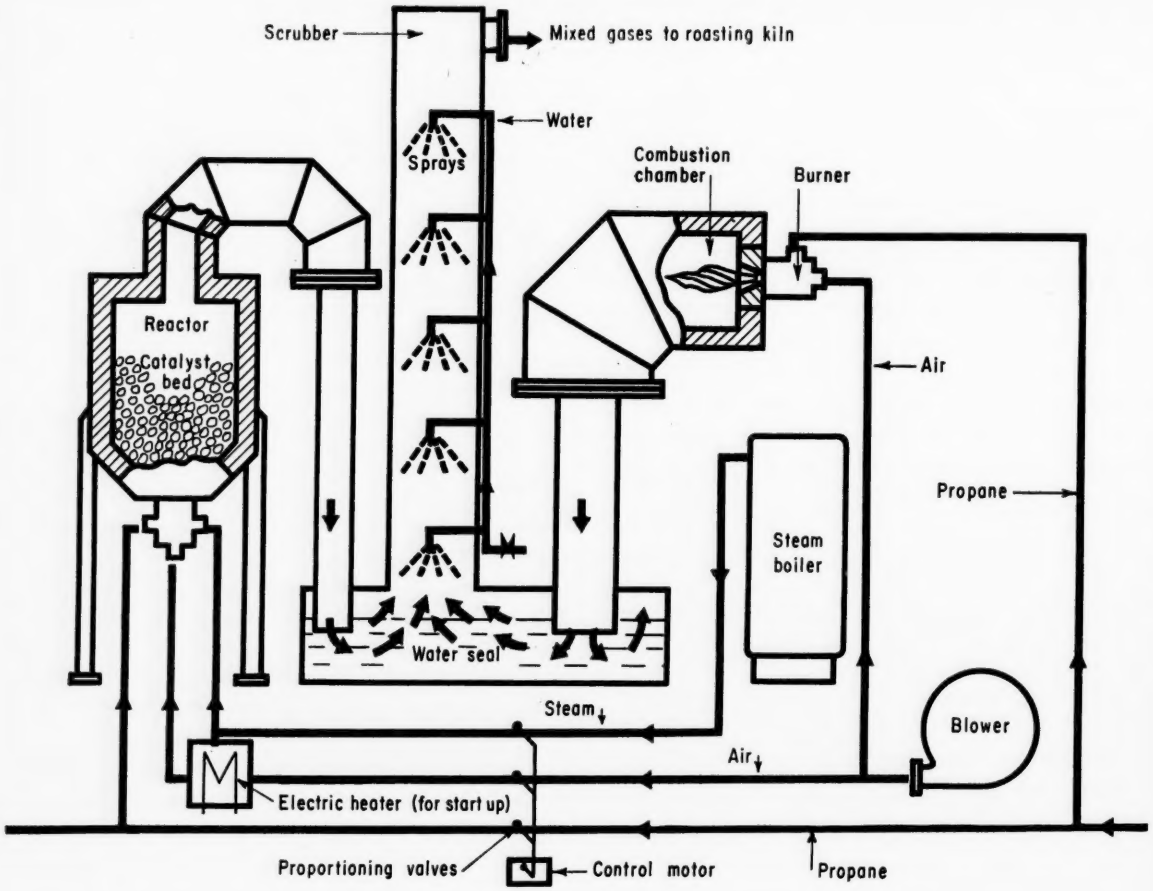


UNIQUE REFORMER GETS FIRST U. S. TRIAL, SUPPLIES REDUCING GAS TO PILOT KILN

Popular European process is playing important role in magnetizing-roasting tests aimed at upgrading Mesabi Range semi-taconite ores.

First U. S. installation of a catalytic autothermic reformer (CAR), used extensively in Europe to produce hydrogen-rich gas (*Chem. Eng.*, April 1957, p. 150), is now operating on Minnesota's Mesabi Range.

It provides a reducing atmosphere in a rotary kiln erected by U. S. Steel's Oliver Iron Mining Div., at its Trout Lake ore concentrator near Coleraine, for pilot studies of a lab-developed method for magnetizing-roasting semi-taconite.

This low-grade, iron-bearing material (25-40% Fe), which is found in large quantities on the Western Mesabi and other Minnesota Ranges, is nonmagnetic, so cannot be beneficiated by the method employed in magnetic taconite plants on the Eastern Mesabi—which crush the ore and remove the iron-bearing particles with magnetic separators.

However, a successful method of separating the iron-bearing material from the semi-taconite could greatly influence Minnesota's future iron mining industry.

Oliver, therefore, instituted an extensive research program at its Duluth Research Lab, using all known concentrating techniques. Selected as the most feasible method was magnetizing-roasting, by which the semi-taconite is converted to the magnetic form—after which the material is ground, concentrated and agglomerated by the conventional method for use in blast furnaces.

▶**Kiln Is Key** — Basic piece of equipment in the pilot plant is a 4½-ft.-dia. x 50-ft.-long, brick-lined rotary kiln (capacity up to 5 tons ore/hr.). The ore is heated in it to 1,500 F. (To insure exclusion of air, Oliver's kiln was specially designed and built with sealed ends.)

A mixture of H_2, CO and other gases, produced from propane in the CAR reformer, is fed to the kiln. This provides the reducing atmosphere that makes possible conversion of the semi-taconite to highly magnetic ore, according to the following equations:

$3Fe_2O_3 + H_2 \rightarrow 2Fe_3O_4 + H_2O$

$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$

Composition of the reformed gas entering the kiln is approximately 35% H_2, 15% CO, 40% N_2, 5-8% CO_2, plus traces of methane and other gases.

▶**Versatile Unit**—Oliver selected the CAR gas reformer because it is relatively simple to operate and clean, and is easily adapted to numerous fuels such as natural gas, lignite or coal, as well as propane.

Unlike most other catalytic reforming processes, CAR doesn't require an externally fired, tubular converter; its converter is simply an insulated vessel containing a single bed of catalyst, operating at 1,300-1,600 F.

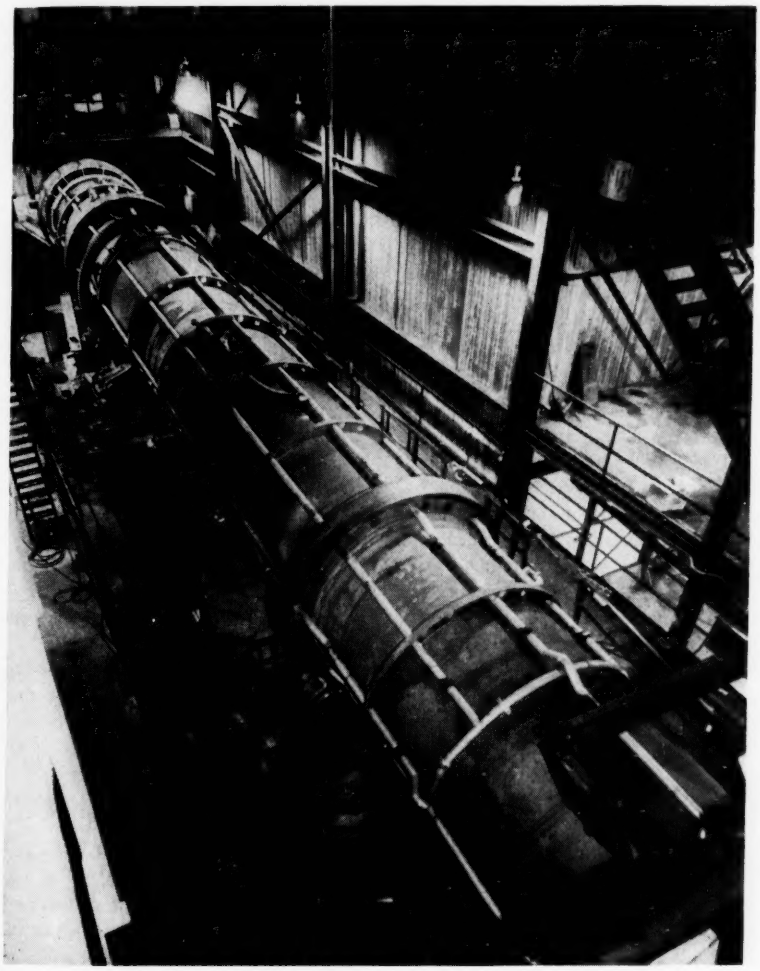
The unit operates continuously, and bypasses the need for oxygen supply—which is characteristic of partial oxidation processes for hydrogen.

Heart of the CAR unit (built by U. S. licensee, The Gas Machinery Co., Cleveland) is a refractory-lined, conical-bottom reformer that is partially filled with a nickel catalyst (see accompanying diagram).

To start the reaction, the air is heated electrically, then mixed with propane vapor and steam. Once started, however, the reaction is exothermic, so external heating is discontinued.

For use in the pilot kiln, the reformed gas is mixed with CO_2 and N_2, which is produced by combustion of propane in a special chamber. Mixed gases are then cooled and scrubbed before they are fed to the kiln.

Steam is generated in an automatic, propane-fired Type W, Sellers vertical boiler, operating at 15 psig. Output of the CAR unit is 33,000 cu. ft./hr.—AVG



Ore roasting kiln at Cooley, Minn. plant of M. A. Hanna Co., is similar, but larger (8-ft.-dia. x 80-ft.-long) than the one used by Oliver.

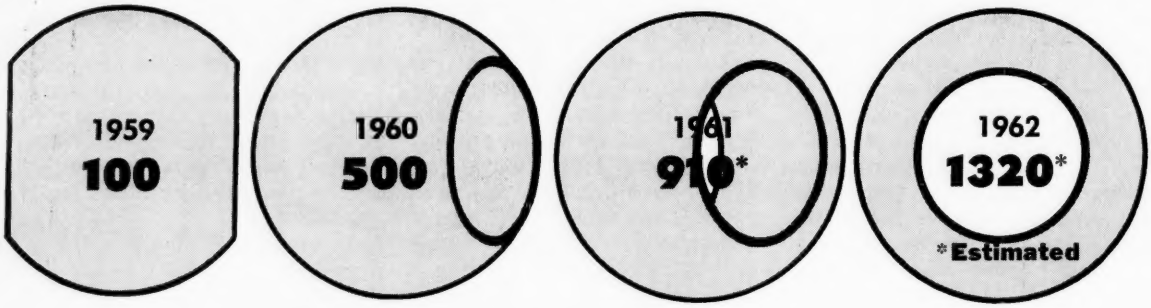
Fuel Oil Forges Its Way To Role In Ironmaking

Esso Research & Engineering thinks it has found a 100-million-bbl./yr. market for fuel oil: iron-producing blast furnaces. Esso already has an experimental fuel-oil injection project at Dominion Foundries & Steel, Hamilton, Ont. (*Chem. Eng.*, Nov. 14, 1960, p. 108). And the firm has also been working closely with U. S. Steel and the U. S. Bureau of Mines.

Oil in a blast furnace serves a dual function: it supplies part of the furnace's heat requirements and it also furnishes hydrogen for reducing the iron ore. Both factors reduce the consumption of expensive metallurgical-grade coke.

Esso's latest tests show that, at low oil-injection rates (90 lb./ton of hot metal), 1 lb. of oil replaces about 2 lb. of coke—and increases the furnace's production rate 19%. At higher injection rates (384 lb./ton), 1 lb. of oil replaces about 1 lb. of coke. Although the higher injection rate is not as efficient from a production standpoint, it is economically attractive in areas where the price of coke greatly exceeds that of oil.

Here's how sales have grown (1959 = 100)



BALL VALVE STORY: LUSTY NEWCOMERS LOOM LARGER

In less than a decade, they have grown from highly specialized devices to dependable stock items, handling increasingly tougher CPI valve applications.

Instead of better mousetraps, equipment makers are building better ball valves—and the engineers of the CPI are beating a path to their doors. Indeed, product-improvement announcements appear more and more frequently, and the engineer with a valving problem is the better for it.

The CPI's growing dependence on the ball valve for a variety of standard and special uses stems directly from advances made in valve performance, which have extended the temperature and pressure operating ranges of the units to encompass most process needs in the chemical industry today.

Consequently, ball valve sales soared from practically nothing ten years ago, to an estimated $20 million plus last year; and those companies reporting on 1961 sales expect year-end totals to show an increase over 1960 of from 50 to 150%.

▶ **Competition Spurs Progress**—As might be expected, the number of companies making and selling ball valves has increased—from a half-dozen in 1956 to almost five times that many today (see accompanying panel). This influx has created strong competition, spurring the development of new concepts in design, materials and service—and simultaneously intensifying marketing and distribution problems.

While still only a minor influence in the almost-$2-billion valve market, ball valves have been finding an increasing acceptance, and their rate of usage is growing faster than that of valves in general.

The features that make ball valves desirable for many applications are also the reasons for the upsurge:

• *Tight shutoff, long-lasting seal*—Almost every unit has an elastomer seal between the ball and the body. Not only does this seal accommodate itself to any space between the two members, but it wipes accumulated material off the ball, reducing wear. When the valve is closed, line pressure intensifies the sealing action, so the higher the pressure on the fluid being restrained, the tighter the seal.

• *Full opening*—Pressure drop through ball valves is negligible, since the full-opening passage in the ball matches pipe diameter. Low turbulence produces minimum wear on valve internals.

• *Fast operation*—Just ¼-turn of the ball can change a flow from full flow to nothing. This is particularly advantageous where quick shutoff is needed for precise measuring of a batch of material. The simple movement also simplifies the job of automatic control equipment that may be attached.

• *Other advantages* — Because of its sealing mechanism, little force is needed to operate the valve. Hence, external equipment needed to turn even large-diameter units is usually compact. Unlike valves with circular handwheels, ball valves are usually fitted with lever-type handles that, when aligned with the flow passage in the ball, give immediate visual indication of the position of the valve opening.

And ball valves take less maintenance. Most never require lubrication, cutting down on possible contamination.

▶ **The Other Side of the Coin**—To be sure, ball valves have disadvantages, some of which are inherent. To begin with, while many units are used for control purposes, throttling operation is not the valve's strong point. They develop an appreciable pressure drop — higher than some other types of control valves—and are particularly susceptible to wear on exposed portions from action of the flowing medium. Further, most types trap material in the ball passage when closed—which may rate as a contamination factor.

Temperature limitation is another disadvantage. This, however, is rapidly being overcome. Rubber elastomers are good in a range of −20 to +225 F.; with Teflon—particularly when reinforced — the range is −425 to +600 F.

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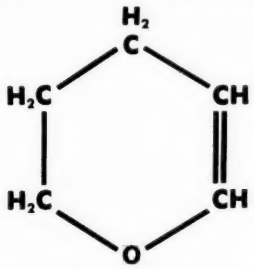

QO Dihydropyran is a colorless, mobile liquid of ether-like odor; it is very reactive, the activity is centered around the double bond. Alcohols add readily to the double bond in the presence of acids to give an acetal from which the alcohol can be regenerated. This gives a useful method of protecting the alcohol group during reaction. Dihydropyran also exhibits properties of a vinyl ether. Bulletin 137 describes many more reactions.

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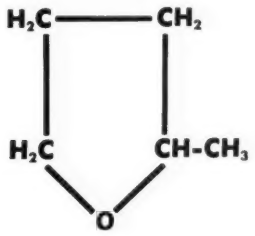

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−70	FREEZING POINT, °C	−136
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0	FLASH POINT, °F (Tag closed cup)	12
1.6(25°C) 0.5(25°C)	SOLUBILITY g./100g. H_2O g.H_2O/100g. chemical	15.1(20°C) 5.3(20°C)
9.8(b.71-2°C)	WATER AZEOTROPE % water	—
34.9 57.0 — 148.0 — 302.0 — 600.00	VAPOR PRESSURE, mm. of Hg at 0° 10 20 30 40 50 60 70	37.8 64.5 102 165 248 366 536 —

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Recently, nonmetallic graphite-based seals have pushed the frontier to 1,000 F., an upper limit that embraces most chemical and petroleum processes.

▶Individual Characteristics — Many manufacturers have incorporated special features in their valves, which undoubtedly have contributed to the phenomenal growth of ball-valve use. Here are a number of important differences and improvements:

An interesting development is the Conosphere unit by ACF Industries, WKM Div. The ball is surrounded by a molded Teflon capsule that provides all seals. Inserted or replaced from the bottom in three minutes, the capsule is held in place by a bottom plate that adjusts the tightness of the seal.

American Chain & Cable, and Ball Valves, Inc., have similar units with spring-loaded seats that seal in either direction against pressure or vacuum.

Some of the largest ball valves in the world are built by Cameron Iron Works, whose standard units run to 36 in. A unique feature is a projection on the ball that engages gearlike teeth on the seat ring, rotating the seat a fraction of a turn each time the valve is opened. Wear on areas that are impinged upon by high-velocity flow is thus evenly distributed.

Clayton Mark & Co., builds valves to withstand up to 2,500 psi. To simplify installation and maintenance, units have double-union ends, thus require no additional fittings.

Ball valves provided by Colonial Plastics contain no metal parts, stand up well to corrosive fluids. Good to 150 psi., they may be adjusted externally to align ball, stem and seats.

For vacuum service, a model built by Consolidated Vacuum has a small hole in one side of the ball, to permit evacuation of the ball chamber when the valve is closed. Three-piece design allows center section to be removed without disturbing union ends.

A spring-loaded, wedge-seat design by Hills-McCanna permits the use of nonresilient seats. With Graphitar, a graphite-based material, operating temperatures of 1,000 F. are possible. Also, metal-encaged or reinforced Teflon seats can be used in hazardous areas, since the metal forms a backup seal in the event that the main seals are destroyed by fire.

Hoke, Inc. has a stainless steel model for high-pressure work to 3,000 psi. The inline design simplifies installation and maintenance.

Features of Hydromatics Inc.'s ball valve are top entry for quick maintenance; and top and bottom guidance for the ball, to protect seats against distortion. Sized to 36 in., rated to 3,000 psi., the stainless steel model with Teflon seats and seal can withstand 15 min. of open flame without losing its seal.

Leakage is prevented at the stem in Homestead Valve's unit that has Teflon barrel packing and a stem shoulder that prevents the ball from being forced downward. Screw-in tail pieces at both ends are also gasketed against leakage.

Unique sealing feature is provided in Hydril Co.'s valve. A handwheel rotates the value to a closed position via gearing, then compresses a confined packing ring to form a tight seal. In opening, the ring is released before the ball turns. This valve gives good service where differential pressures are involved. Sizes to 24 in. are good to 3,000 psi.

For high pressure, Jamesbury's unit body construction and compact design serves at up to 4,500 psi. For hazardous applications, valves contain a special metal lip to back up resilient seal, and are rated fire-safe.

Lunkenheimer's valves have top entry, permitting all internals to be removed and inspected without disturbing the piping. A square stem-hole permits ball to float vertically for self-alignment.

Fire-safe performance is provided by Pacific ball valves that operate to 2,500 psi. Sizes above 2½-in. have an adjustable seal compression ring for optimum compression, two-way sealing. Special stem

U.S. Ball Valve Manufacturers

ACF Industries, Inc., WKM Div.	P. O. Box 2117	Houston, Tex.
Allis Chalmers Mfg. Co.	56 No. Queen St.	York, Pa.
American Chain & Cable Co., Inc., R-P&C Div.		Reading, Pa.
Ball Valves, Inc.	41 Jackson St.	Worcester, Mass.
Cameron Iron Works	P. O. Box 1212	Houston 1, Tex.
Chemtrol Corp.	404 Central Ave.	Santa Ana, Calif.
Clayton Mark & Co.	1900 Dempster St.	Evanston, Ill.
Colonial Plastics Mfg. Co.	2691 E. 79th St.	Cleveland 4, Ohio
Consolidated Vacuum Corp.	1771 Mt. Read Blvd.	Rochester 3, N. Y.
Cooper Alloy Corp.	100 Bloy St.	Hillside 5, N. J.
Crane Co.	836 So. Michigan Ave.	Chicago 5, Ill.
Electric Steel & Foundry Co.	2141 NW 25th Ave.	Portland 10, Ore.
Fairbanks Co.	395 Lafayette St.	New York 3, N. Y.
General Kinetics Co.	197 So. Van Brunt St.	Englewood, N. J.
Hills-McCanna Co.	400 Maple Ave.	Carpentersville, Ill.
Hoke, Inc.	1 Tenakill Park	Cresskill, N. J.
Homestead Valve Mfg. Co.	11 Johnson St.	Coraopolis, Pa.
Hydril Co.	714 W. Olympic Blvd.	Los Angeles 15, Calif.
Hydromatics, Inc.	5 Lawrence St.	Bloomfield, N. J.
Jamesbury Corp.	45 New St.	Worcester, Mass.
J. L. Putnam Co., Inc.	460 Smith St.	Biddleford, Me.
Lunkenheimer Co., The	Beekman St. at Waverly	Cincinnati, Ohio
Pacific Valves, Inc.	3201 Walnut Ave.	Long Beach 7, Calif.
Pelton Div., Baldwin-Lima-Hamilton Corp.	19th & Holcomb	San Francisco, Calif.
Rockwood Sprinkler Co.	38 Harlow St.	Worcester 5, Mass.
Strong, Carlisle & Hammond	508 Sandusky St.	Conneaut, Ohio
Tube Turns Plastics, Inc.	30th & Magazine Sts.	Louisville 11, Ky.
Walworth Co.	750 3rd Ave.	New York 17, N. Y.
Worcester Valve Co., Inc.	20 Parker St.	Worcester, Mass.

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In the designers mind . . . on the drawing board . . . in the research laboratory . . . new methods and ideas for corrosion protection are constantly being developed by Ceilcote. Objective recommendations are based on the proper combination of materials, experience and broad multi-product coverage. At Ceilcote, each customer inquiry, big or small, receives the same analytic treatment. First . . . the RESEARCH DEPARTMENT reviews and recommends proper construction materials for maximum chemical resistance . . . then . . . DESIGN ENGINEERING for structural design calculations . . . next . . . GENERAL ENGINEERING provides exact cost-estimating and co-ordinates research findings and design calculations with production and construction departments. The results of these detailed efforts maintains Ceilcote's established leadership in the field of corrosion-proof equipment and construction.

An open invitation to inspect our plant and facilities is extended to Ceilcote's customers and prospective customers. Please let us know in advance of your visit.

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PROTECTIVE LININGS AND COATINGS

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CEILCOTE CORROSION-PROOF MATERIALS AND CONSTRUCTION FOR INDUSTRY

packing is provided for vacuum service.

An early pioneer who first turned out ball valves in 1945, Rockwood Sprinkler uses a spring behind the ball that acts through the ball retainer to provide low-pressure sealing in either direction.

Strong, Carlisle & Hammond's valve has bar-stock construction and top-entry design. Unit handles 350 F. at up to 150 psi., and seals well at low pressure.

Top entry and top adjusting are features of valves molded by Tube Turns Plastics. Highly corrosion-resistant, the Penton valve is rated to 125 psi., withstands 250 F.

Walworth Co., builds ball valves up to 36 in. that withstand 450-500 F. Larger sizes have a unique seal wherein the ball has no freedom to float, and the ball seats—supported by an O-ring—seal to the ball under line pressure.

Worcester Valve provides two-way sealing, making its valve desirable for vacuum and manifold applications. For easy maintenance, the body can be removed from the pipe ends by loosening four bolts. Five different types of pipe ends may be used interchangeably.

These descriptions present only the highlights of each manufacturer's line. Most companies supply a complete line of ball valves, built around the feature described.—FCP

FROTH PROCESS WHIPS UP FOAMS

A two-stage foaming technique shows promise in panel manufacture. Secret: adding a volatile fluorocarbon to urethane foam reactants.

Du Pont is offering a novel technique for foaming urethanes to the foam industry. The process was described by the firm's R. E. Knox at the recent AIChE meeting in Lake Placid, N. Y.

Key to the route is addition of a volatile liquid, usually dichlorodifluoromethane, to the reactive polyurethane mixture, under pressure. When pressure is reduced, the fluorocarbon vaporizes and produces a froth. The frothed foam then completes its expansion from additional gas evolution and heat generated by the reaction between the diisocyanate and water.

Froth technique is claimed to be especially suited for void filling and panel manufacture for two reasons: (1) the partial expansion of the froth before it fills the voids prevents excessive pressure buildup on foam molds; (2) froths can be deposited directly on expanding foam without danger of foam collapse or density variations. In addition, froth foams offer lower and more uniform densities than are obtained by conventional techniques.

Adoption of the process on a commercial scale has been held back by a lack of mixing equipment that will operate at the required pressure. Knox says, however, that commercially available mixers now used for urethane foam mixing can be adapted to froths, providing that they are modified to work at pressures up to 200 psi., and are fitted with a pressure letdown system.

Basically, process involves the dispersion of the fluorocarbon liquid in the urethane reactants at around 90-110 psig. Reactants then pass through the letdown system that controls the efficiency of gas utilization and froth flow characteristics. As the fluid discharges from the letdown valve, it changes from a liquid to a gas-liquid mixture; exiting velocity for normal froth production is around 10 ft./sec. Velocities in excess of 100 ft./sec. are used for spraying or forcing the froth into thin molds.

Froth densities of 4-10 lb./cu. ft. leaving the letdown valve generally give optimum utilization of frothing agent with minimum pressure buildup in the mold. These froths yield final foams in the 1.5-2.5 lb./cu. ft. range.

Ammonia Blanket Gives Low-Biuret Urea Prills

A new approach to making urea prills with low biuret content was described by P. J. van den Berg, of Dutch State Mines' Central Laboratories, at the ACS meeting at Chicago in September.

Biuret is a decomposition product that tends to form when urea is heated to high temperatures such as are required for making prills. In some of urea's fertilizer applications, presence of biuret is harmful.

In Dutch State Mines' process, which is still in development stages, prills go from the prilling tower to a vessel where they are blanketed by ammonia under pressure. This treatment causes the biuret to revert to urea.

Citing one set of operating figures, van den Berg reported that the biuret content of prills produced from a 284 F. urea melt could be lowered to 0.2% by treatment with ammonia at about 80 atm.

Phosphate Fertilizer Helps Fireproof the Forests

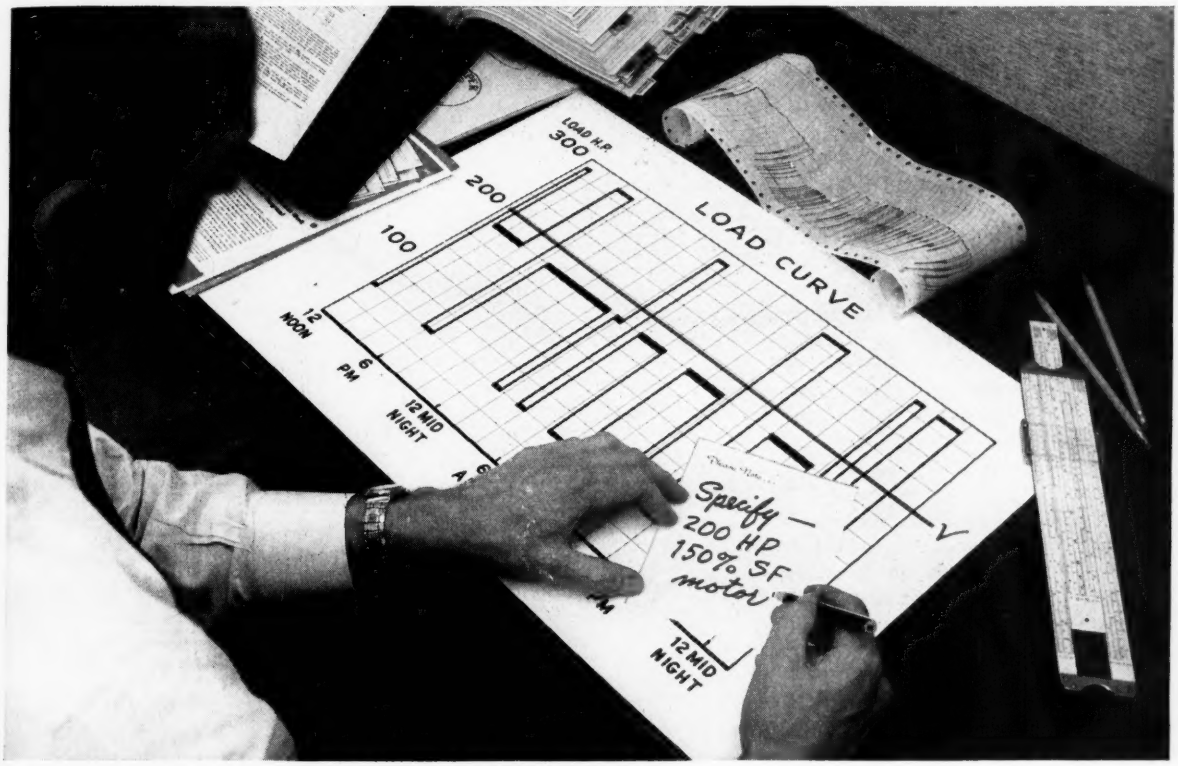
Once regarded as only fertilizer constituents, diammonium phosphate and ammonium sulfate now have a more dramatic use—protecting our forests.

At Riverdale, Calif., the U.S. Forest Service is evaluating the fire-fighting effectiveness of these two chemicals when sprayed on foliage endangered by forest fires. So far, tests have shown diammonium phosphate to be as effective as the borates and bentonite clays ordinarily used. Besides preventing foliage ignition, the phosphate acts in its old role of fertilizer after being rain-washed into the soil. Borates, on the other hand, may actually destroy vegetation.

Rough estimates show the phosphate to be 30% cheaper than the borates now used in fighting forest fires.

SILICONE NEWS from Dow Corning

Over-motoring Out-moded



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Specifying motors with nameplate horsepower rated for peak load conditions is rapidly being out-moded as too expensive.

Today, it's far more economical . . . and just as reliable . . . to specify silicone insulated extra service factor motors with horsepower ratings based on nominal load conditions.

Additional horsepower output — up to 50% above nameplate rating — is available for peak loads.

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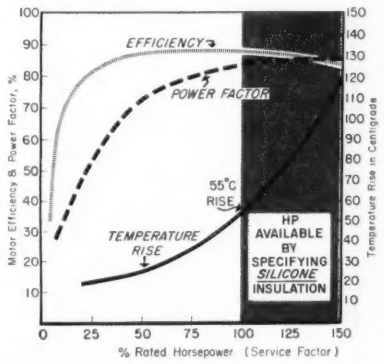
Additional savings in several ways: additional nameplate horsepower is usually more expensive than the extra service factor silicone insulation provides; additional horsepower requires extra floor space and heavier mountings; over-motoring power factor problems are eliminated or minimized.



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COMPETITION SHARPENS IN CHLORINATED SOLVENTS

Overcapacity, growing imports, less-costly blends, stymie domestic production, put burden on marketing and selling techniques.

When the growth rates of an industry fade, competition gets rough. Prices falter, salesmen curse and researchers strain to find ways to beat the competition. That's the story of chlorinated solvents today.

Right after World War II, this segment of the chemical industry began to grow rapidly and didn't slow down until the mid-fifties, when the forces of a recession, imported solvents and overcapacity took hold.

In 1960, annual domestic trichloroethylene capacity (485 million lb.) topped consumption by some 77 million lb. Perchloroethylene capacity, estimated at 300 million lb./yr., exceeded consumption (231 million lb./yr.). And even methylene chloride production (113 million lb./yr.) didn't utilize domestic capacity (140 million lb.).

Now, U. S. producers are trying to revive the healthy growth rate they once enjoyed. So far, they have had only partial success.

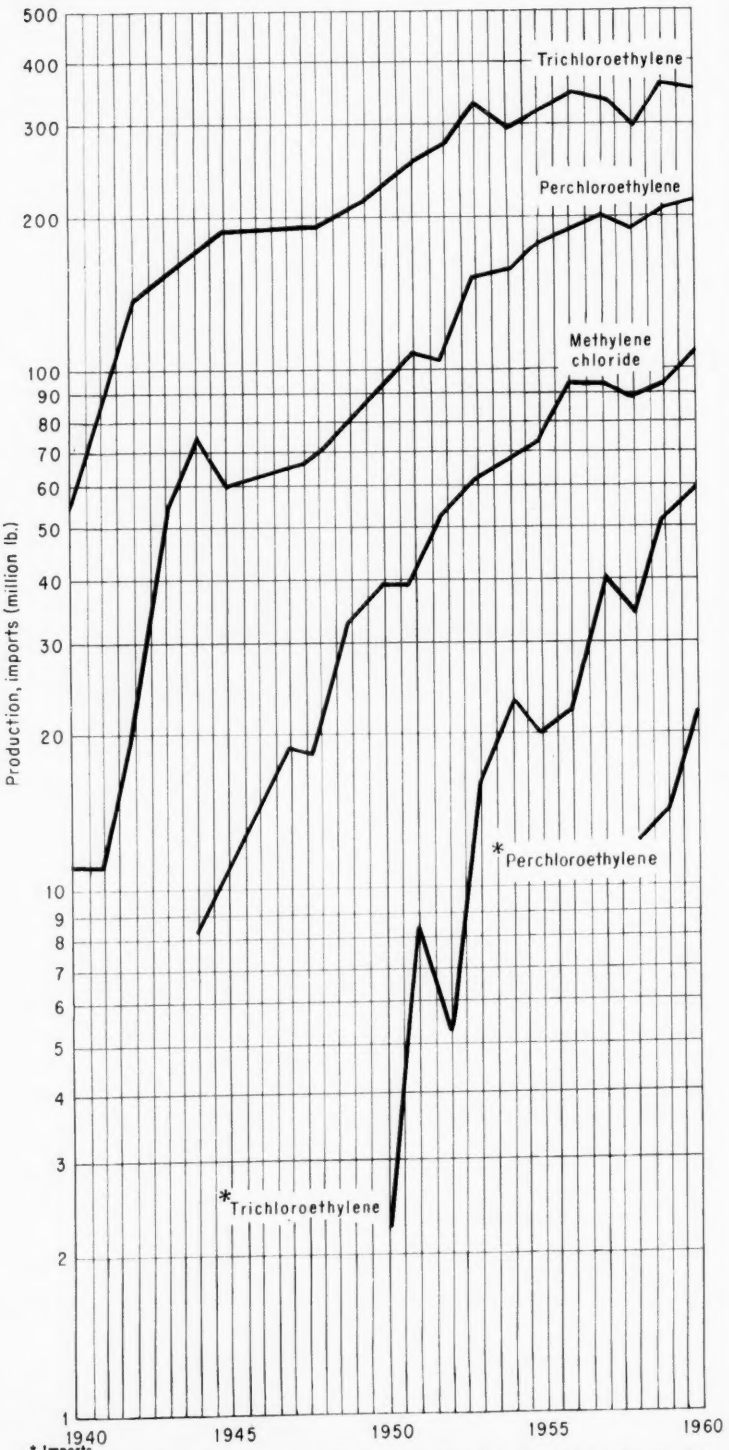
► **Eyeing the Specs**—To some observers, specifications for purity and performance of chlorinated solvents have become marketing weapons rather than a valid reflection of customer needs.

Manufacturers often help customers institute new or different standards of quality, based on a variety of intricate tests. But some look askance at this practice, claiming that such tests serve only to befuddle other producers bidding for the customer's business. As one old timer flatly stated, "98% of all these specs don't mean a thing".

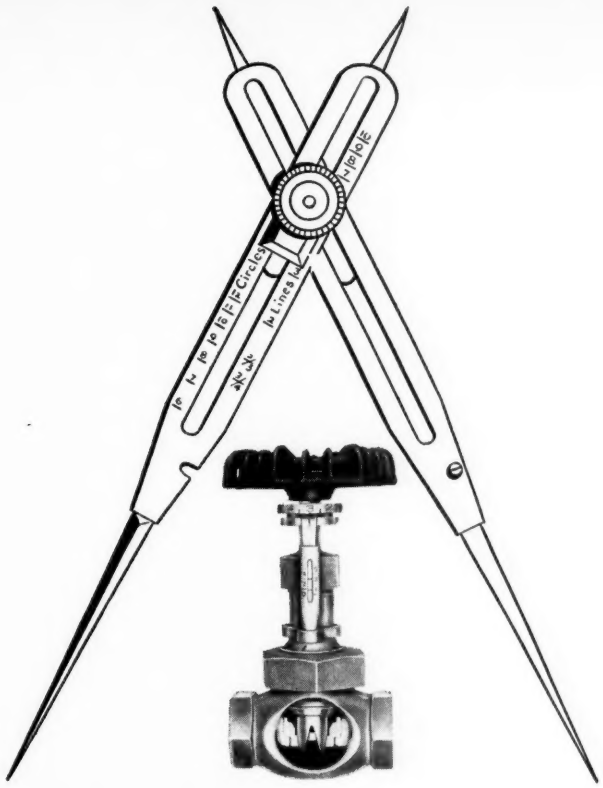
Less-outspoken critics point out that rigid specifications are necessary, but that most customers don't need all the features that producers build into their solvents.

However, manufacturers counter that: today, solvents are being used, run through a recovery system, and used again. Such rugged

Imports soar to saturation point as U. S. production peaks out.



* Imports
Sources: U. S. Tariff Commission; U. S. Department of Commerce; Dow Chemical Co.; CE estimates.



PROPORTIONER

controls flow to save for you

The V-port disc in all Hancock "Flocontrol" Valves insures proportional flow throughout the entire lift of the stem. They are valves that help you achieve uniform product quality through closer control, save steam and fuel on process work, and cut maintenance costs.

"3 in 1" valve design combines variable orifice with shut-off and micrometer dial and pointer. The valve opening can be set within 1/10 turn of the handwheel —you can duplicate all settings easily, instantly. No shut-off valve required–flow is in a straight line, with separate shut-off seating surface located away from the V-ports.

Hancock "Flocontrol" Valves are available in Bronze and Steel to meet the most demanding services. Ask your industrial supply distributor for details.

Hancock "Flocontrol" valves assure positive pinpoint control—eliminate all guesswork.

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conditions require equally rugged solvents. Therefore, a safety factor has to be built in.

Latest controversy on this subject swirls around an effort to establish an acceptable liquid-oxygen impact sensitivity test, which will pass or fail solvents intended for cleaning missile fuel systems. So far, missile makers haven't come to any decision.

There's plenty of capacity

TRICHLOROETHYLENE

Producer	Est. Capacity (million pounds)
Columbia-Southern Chemical	
Barberton, Ohio	45
Detrex Chemical Industries	
Ashtabula, Ohio	75
Dow Chemical Co.	
Freeport, Tex	35
Baton Rouge, La	35
Du Pont	
Niagara Falls, N. Y.	225
Hooker Chemical Corp.	
Niagara Falls, N. Y.	45
Tacoma, Wash	25
Total	**485**

PERCHLOROETHYLENE

Producer	Est. Capacity (million pounds)
Dow Chemical	
Freeport, Tex	60
Pittsburg, Calif	30
Baton Rouge, La	30
Du Pont	
Niagara Falls, N. Y.	50
Diamond Alkali	
Deer Park, Tex	45
Columbia-Southern	
Barberton, Ohio	30
Stauffer Chemical	
Louisville, Ky	20
Detrex Chemical	
Ashtabula, Ohio	20
Frontier Chemical	
Wichita, Kan	15
Hooker Chemical	
Tacoma, Wash	...
Total	**300+**

METHYLENE CHLORIDE

Producer	Est. Capacity (million pounds)
Allied Chemical	
Moundsville, W. Va	15
Diamond Alkali	
Belle, W. Va	10
Dow Chemical	
Freeport, Tex	40
Pittsburg, Calif	10
Du Pont	
Niagara Falls, N. Y.	25
Frontier Chemical	
Wichita, Kan	10
Kolker Chemical	
Newark, N. J.	10
Stauffer Chemical	
Louisville, Ky	20
Total	**140**

▶ Imports Pose Threat — According to U. S. producers, importers have been able to capture domestic markets by selling to customers who don't require high-purity solvents, using small price cuts as incentives. On the other hand, U. S. salesmen have based their pitch on high purity and high performance. What has domestic manufacturers worried now is that the quality of foreign solvents has been noticeably improving, and they may soon challenge domestic brands on the latter's own grounds.

Already, one British solvent (containing a U. S.-licensed stabilizer system) is being sold in the U. S. by importers who claim it is the equal of its domestic counterpart. Also, Japanese solvent makers are said to have licked their stabilizer and inhibitor problems, are preparing to jump into West Coast markets.

While domestic producers expect increased competition from imported solvents in the next two years, importers don't see it quite that way. Trichloroethylene and perchloroethylene importers, for example, plan to bring in just enough solvent to maintain their current share of the total domestic market (about 15%). A drive to garner more sales might set off a damaging price-cutting spree, which would be as serious to importers as to domestic makers.

▶ Custom Blends Grow—Through out the U. S. are some 100 to 200 independent firms that can tailor a solvent to nearly any use. To get the desired blend, they take a chlorinated solvent—usually methylene chloride—combine it with an aromatic or aliphatic compound, and add a carefully measured amount of inhibitor or activator. The result: a specialty product that will perform just as the customer wants, and at a unit cost generally lower than that of the pure solvent.

Why don't blended solvents capture more of the market if they are both cheap and adaptable? Manufacturers of the basic solvents say that such blends don't stand up under extended usage.

Consequently, blends have found their best markets in applications where they are only used a few times before being discarded or reclaimed. These markets include makers of aircraft and missiles, paint and varnish removers.

▶ Trichloroethylene—Producers of this solvent are doggedly optimistic. They expect sales to rise at a moderate pace in the years ahead, stimulated by:

- Continual increase in metal fabrication. As a metal degreaser, trichloroethylene is used extensively in fabricators' cleaning systems.
- Missile construction and maintenance. Since cleanliness is such a virtue in high-accuracy space vehicles, cleaning with solvents should increase.
- New applications: phosphatizing, base for new paint mixtures, ultrasonic cleaning.

Success of trichloroethylene as an industrial solvent has depended heavily on its stabilizing system. When exposed to light, heat or water, the pure product decomposes to a complex mixture of acids and other organic compounds. Stabilizing with a small amount (.01-2.0%) of inhibiting chemicals prevents this decomposition, even under the most severe industrial conditions.

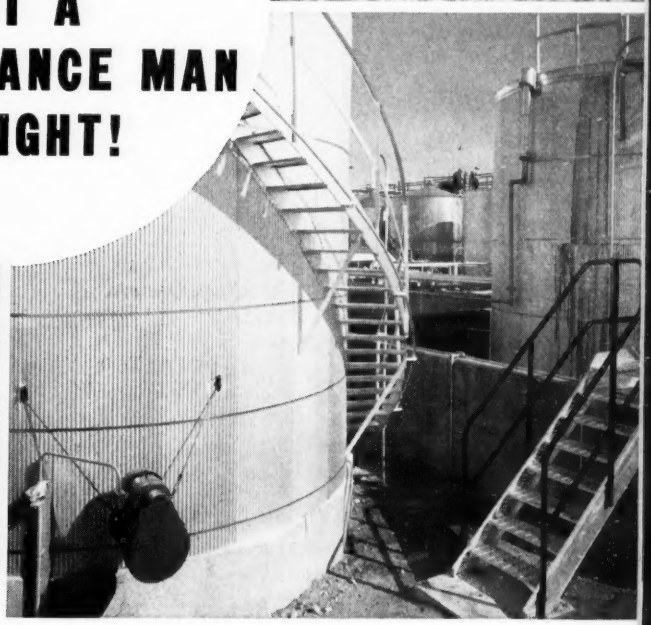
Until 1954, the inhibitors were mostly amines. As acidic decomposition products would form, the amine would neutralize them as well as their effect on the further decomposition of the solvents. Its big drawback: the amine supply would eventually be depleted and the solvent would turn sour.

In 1954-55, Du Pont introduced a non-alkaline trichloroethylene. Stabilized with a six- or seven-component mixture (based on a pyrrole), the new material resisted decomposition far better than the alkaline product containing amines.

Unsuccessful in devising similarly effective stabilizer systems without violating existing patent rights, most other producers then licensed a neutral inhibitor system from Du Pont or FMC Corp.'s Westvaco Div., which also owns broad patent rights on certain inhibitors.

▶ Perchloroethylene—More stable

TROUBLE-FREE MIXING... NOT A MAINTENANCE MAN IN SIGHT!



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Take the Nettco side drive mixer for petroleum and petrochemical applications. Its stuffing box is the easiest to repack — results in less downtime. But more important — you don't have to repack it as often as others. Proper spacing of bearings and the location of the stuffing box relative to the bearings assures its longer wear — guarantees precise alignment of shaft and stuffing box — permits only minimum shaft runout. And — if your particular application requires a mechanical seal, you'll find that the Nettco design, with a bearing at the seal, prevents shaft runout assuring maximum seal life. However, when a seal must be replaced, Nettco makes it easier and faster to change.

Then — there's the extra large chrome plated shaft. Chrome — because it gives it longer life; extra large — because resulting rigidity prevents flexing and excessive wear.

The high gear efficiency of Nettco side-drive mixers requires minimum horsepower. The operating cost is low and you pay no more for the know-how and imagination that make Nettco design refinements possible.

You can reduce maintenance cost and shutdown time on your mixing equipment. See Refinery Catalog or Chemical Engineering Catalog for the nearest Nettco Representative or write us direct for Bulletin 582. Nettco Corporation, 87 Tileston Street, Everett 49, Mass.

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than trichloroethylene, this product needs only a small amount of amine-based stabilizer to prevent its decomposition in dry-cleaning systems—75% of present sales—and metal degreasing operations—⅛ of domestic production. Perchlor makers are hungrily anticipating the success of "coin-op" dry cleaning, being touted by appliance dealers as the successor to the Laundermat.

Though Du Pont is boosting its Valclene (a fluorinated solvent mixture) for use in do-it-yourself dry-cleaning machines, it isn't expected to pose a serious challenge to perchloroethylene. Most solvent producers and laundry equipment makers say that Valclene is too costly as well as too hard to recover. Percholoethylene will also continue to gain on petroleum dry-cleaning solvents, perhaps find more uses in metal cleaning.

► **Methylene Chloride** — While one domestic producer has instituted a price increase, a small importer threatens to lower prices—chaos, as one man describes the market.

Despite the confusion, sales will probably continue to rise, though not as they once did. And importers will play an important part in the marketing story. Most of it will continue to go into paint and varnish removers.

► **1,1,1-trichloroethane** — A recent and successful addition to the industrial solvents family, trichloroethane owes most of its popularity to its low toxicity (maximum allowable concentration: 500 ppm.). Its sales growth has been at the expense of carbon tetrachloride (allowable concentration: 25 ppm.), formerly used as a workaday cold solvent.

Dow, the first to sell trichloroethane in large quantities (as Chlorothene), has increased production capacity. But, according to the company, it won't be long before competition gets just as rough as that in any other solvent market.

Agreeing with Dow, another source points out that, while Dow was able to sell its original 20-million-lb./yr. production, its new 40-million-lb./yr. production rate won't be absorbed by the market for some time.—CRB

CHEMICAL MARKETERS SEE PROFITS VIA SHIFT TO CONSUMER SELLING

A complete turnabout — from product emphasis to customer-orientation—is occurring in chemical marketing. Many believe this is the best solution to the present chemical industry profit squeeze.

"We must be marketers first and production people second—an approach that may be somewhat strange to many of us who were reared in the industrial atmosphere of a chemical company."

Thus, American Cyanamid's T. P. Forbath summed up the decidedly "new look" in chemical marketing, in a paper given before the recent Lake Placid, N. Y., meeting of AIChE. This change from product- to consumer-orientation, which represents a 180-degree shift in Cyanamid's approach to market development, was described by Forbath as follows:

"We have come to the conclusion that in the light of our company's resources and capabilities, our best opportunity for enhancing profit potential lays in forward integration—by developing and producing and selling more products that perform useful functions—e.g., a textile resin, a paper resin, or a flotation agent for the mining industry.

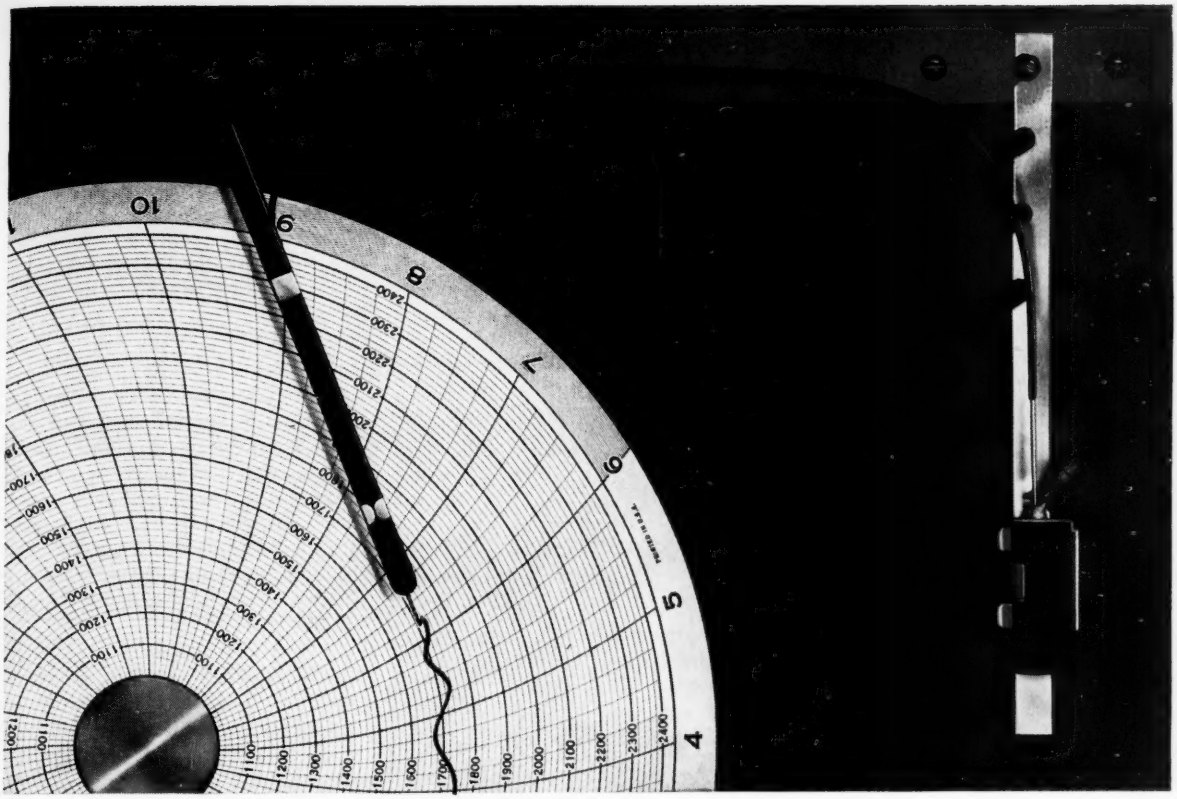
". . . Once we have uncovered a need and have defined it as thoroughly and as specifically as we can, we will strive to tailor-make the product to fill this need. Of course, it is convenient if the best product can be made from our own raw materials, utilizing our own technology. However, this consideration more and more is becoming secondary to that of finding the right product to fill the need at the right time. With the right product and a growing and profitable market, we can perhaps advantageously back into the production of the raw material—or integrate backward *after* the forward integration rather than *before* as has been true most often in the past.

". . . Our chemical business more and more has begun to fabricate its raw products and to learn to market these end-products to the retailer and consumer—necessitating whole new concepts of operation. Major emphasis is on marketing strategy, with the elements of advertising and promotion looming large in the struggle to do the best job of courting our favorite consumer, the housewife. On the other hand, the steel industry, the oil industry, and the coal industry are spreading their wings, and more and more are treading on the ground formerly covered only by the chemical industry. What we are heading towards then, in effect, are 'industrial companies,' rather than 'chemical' or 'steel' companies, with these concerns knowing no bounds in their search for profitable new products and projects.

". . . We define consumer promotable products as products that, while not sold directly to the consumer by us, are sold by our good customer to Mrs. Housewife—and brand identity can be maintained in the process. Many companies in our industry seem to be gradually moving in this direction, to strengthen their position through vertical integration and through the development of strong brand names, which are relatively less vulnerable to business cycles, product obsolescence and customer loss than many industrial products.

". . . Once we have learned to market such products, we of course must consider seriously whether or not the move toward the consumer will place us in direct competition with our customers. This can be a major pitfall, with the net result that sales and profits will be lost rather than improved."

". . . The benefits of forward integration must be carefully weighed against the harm that can result. Unfortunately, there are no general rules to guide us in this area."



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Processes

Taking mercury inventory in chlorine cells via the Australian-developed radioactive technique will be introduced to U.S. chlorine makers by Tracerlab, Inc. Australian Paper Manufacturers, Ltd., which first revealed the method three years ago (*Chem. Eng.*, Sept. 8, 1958, p. 64), has been saving several thousand dollars every time it takes stock of the approximately 1,700 lb. of mercury circulating as cathode in each of its 24 De Nora brine cells at Maryville, Victoria. Former procedure: drain each cell, weigh the mercury. Cost (including downtime) ran close to $6,000. New technique: invest $200 in a vial of radioactive Hg-203, plus about $1,100 for the measuring equipment, and monitor the difference between "before" and "after" Geiger-counter rates. Differential is a measure of Hg-203 concentration, from which total mercury content can be calculated within 1%. Tracerlab is reported to be considering modifications to suit U.S. cells, one of which may be the substitution of Au-198 for Hg-203.

Secondary recovery of oil has been boosted from 2% of the oil in place to more than 70%, at Pan American Petroleum Corp.'s Shannon Pool, Wyo., field. The method is underground combustion, as described by D. R. Parrish, R. W. Ransch, K. W. Beaver and H. W. Wood in a paper presented at the Oct. 8-11 meeting of the Society of Petroleum Engineers of AIMMPE, in Dallas. The trick was tried in Pan American's original combustion pilot project (which includes four additional wells). Production now exceeds 70,000 bbl., and fire breakthrough has occurred at only one well.

Glycerin via allyl alcohol route is the design for Olin Mathieson Chemical Corp.'s multimillion-dollar, 40-million-lb./yr. glycerin plant, now under construction at its Doe Run complex in Brandenburg, Ky. First step in the new route involves a lithium phosphate catalyst, which Olin reports gives good yields of highly pure allyl alcohol from propylene oxide feedstock. Novel technique also regenerates the catalyst. The alcohol can either be converted to glycerin or epichlorohydrin; Olin plans to make glycerin exclusively. Announcement of the new plant and process comes a scant half-year after Atlas Chemical Industries Inc. announced a 50-million-lb./yr. glycerin unit to be built near Wilmington, Del.—also to use a new route (*Chem. Eng.*, May 1, p. 120).

Plants

National Aeronautics and Space Administration has picked a 1,100-acre site near Houston for the command center of the nation's $20-billion try at landing a man on the moon by 1970. Construction of the manned-spaceship laboratories and headquarters will begin early next year, probably costing $60 million to complete. The Houston acreage is being provided rent-free on a long-term basis by Rice University. Previously, Humble Oil & Refining Co. had donated it to Rice with the understanding that it would be used for this purpose.

Hercules Powder Co. has placed its polypropylene fiber plant on stream at Covington, Va. Initial 12-million-lb./yr. capacity can readily be expanded.

Allied Chemical Corp.'s Plastics Div. has doubled polyethylene capacity at Orange, Tex. Expansion boosts plant potential for low- and high-molecular-weight polyethylenes from 11 million to 20 million lb./yr.

Air Reduction Sales Co. will build and operate a $3-million oxygen plant in Huron, Ohio, next door to Du Pont's now-abuilding methanol facilities (*Chem. Eng.*, May 1, p. 121). Due on stream late next year, the 250-ton/day unit will pipeline high-purity oxygen to Du Pont for use in the production of methanol. Some nitrogen will also be piped to Du Pont.

International Minerals & Chemical Corp. has officially opened its $650,000 barite plant in Houston. Capable of processing 120,000 tons of barite ($BaSO_4$) annually, facility will supply drilling-mud companies throughout the South.

Tenneco Chemical Co. has awarded Crawford & Russell Inc. the design contract for its 200-million-lb./yr. vinyl chloride monomer plant on the Houston Ship Channel (*Chem. Eng.*, Mar. 6, p. 151). Facility will "employ newly developed techniques in vinyl chloride manufacture," says Tenneco's president guardedly.

Allied Chemical Corp.'s General Chemical Div. has completed a laboratory addition at Morristown, N. J., that more than doubles its research facilities. The three-story building accommodates 500 researchers and supporting personnel.

California Oil Co.'s Eastern Div. has awarded Badger Mfg. Co. a contract to design, engineer and construct a 30-million-lb./yr. phthalic anhydride plant at Perth Amboy, N. J., by next fall. The fixed-bed, *o*-xylene-fed unit will be operated by California Oil for California Chemical Co.'s Oronite Div.

Continental Oil Co. will construct natural-gasoline recovery facilities in the company's Sacatosa field, 25 miles east of Eagle Pass, Tex., near the Mexico border. Scheduled for completion by next March, the plant will process natural gas at rates up to 2.5 million cu. ft./day, producing 18,000 gal./day of propane, butane and gasoline.

Southwest Potash Corp., a division of American Metal Climax Inc., plans to begin test and break-in operations at its $7-million potash

Turn to p. 146 for more CPI News Briefs

BULLETIN:

New Shell pocket computer helps calculate the evaporation rate of a hydrocarbon solvent in minutes—can be used right at your desk

Shell has invented a handy six-inch computer that lets you calculate solvent evaporation rates at your desk. It's called the Evapo-Rater.*

Here's how it can save you time and help avoid costly trial and error experimentation.

FOR THE first time you can determine solvent evaporation rates without leaving your office.

Shell's new Evapo-Rater does the work for you.

Supplements laboratory device

For years manufacturers have been familiar with the Shell Thin Film Evaporometer—used to determine evaporation rates.

But the Evaporometer resides in laboratories. It is expensive and time-consuming to operate. And it stands about 3 feet high.

So now Shell has invented the new six-inch Evapo-Rater, shown above.

Gives answer in minutes

The new Shell Evapo-Rater is based upon hydrocarbon evaporation rates determined by the Thin Film Evaporometer. It approximates results you can obtain with an Evaporometer, and gives you an answer in a matter of minutes.

The Shell Evapo-Rater makes selection of the correct hydrocarbon solvent quicker and easier than ever. It reduces the need for extensive trial and error experimentation.

New Shell Evapo-Rater, above, determines solvent evaporation rates in minutes. Shell is offering the Evapo-Rater to help users select the correct hydrocarbon solvent.

Works for blends of solvents

And it permits you to determine the evaporation rates for *blends* of hydrocarbon solvents as well. All this can save you valuable time and money.

A limited supply of Evapo-Raters is available for solvent consumers and can be obtained from your local Shell Oil representative. Call him today.

For address of nearest Shell representative, write Shell Oil Co., 50 West 50th Street, New York, N.Y.

SHELL

A BULLETIN FROM SHELL
—where 1997 scientists are working to provide better products for industry

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FLUOROSILICONES: BUILT-IN SOLVENT RESISTANCE

Fluoroalkyl substitution on silicone polymers leads to a new line of lubricants, greases and rubbers that are packed with solvent resistance, and withstand heat and cold.

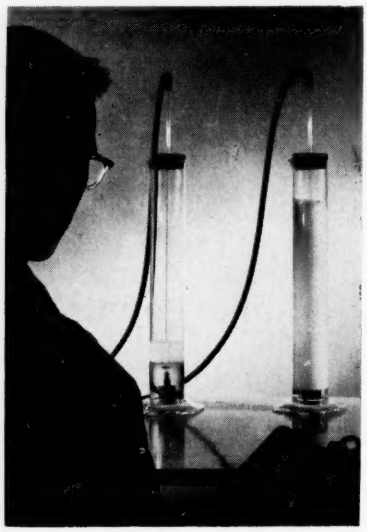
Fluorosilicones are among the more recent polymers to be offered to industry. Their introduction goes back to 1956, when Dow Corning Corp. put Silastic LS, a fluorinated silicone rubber of low swell, on the market. Now, after five years of market-testing that product, the company is supplying a complete line of fluorosilicone fluids, greases and rubbers.*

While exhibiting many of the useful properties that characterize silicones (i.e., antifoaming action, water repellency, stability to heat and oxidation), these new compounds are more powerful lubricants and possess an exceptional resistance to solvents and fuels.

Basic chemical difference between silicones and fluorosilicones is quite simple. Silicones usually have methyl groups attached to the siloxane polymer, whereas fluorosilicones are produced by substituting fluoroalkyl groups for some of the methyl groups. This substitution is responsible for the greater solvent resistance and lubricating properties of the new polymers.

The substituent chosen by Dow Corning is trifluoropropyl. According to the company, the fluorine atoms on the γ carbon of trifluoropropyl make a more stable end-product; fluorines in the α or β carbons have been found to be unstable.

Higher homologs than propyl could be substituted, but they were found to decrease solvent resistance. And additional fluorination along the longer alkyl chain would only increase cost without real improvement in properties.



► **Key Steps**—In the synthesis of fluorosilicones (see cut), new technology is evident in the trifluoropropyl substitution, and in the catalysis to straight-chain polymers from the cyclic intermediates.

Process details will be kept secret for some time, but in answer to a CHEMICAL ENGINEERING question, the company reports that the cyclic intermediates formed during polycondensation of silandiols are stereospecific compounds. Somewhere between ring breakage and chain termination, however, the orderly stereospecific structure is lost, and the polymer shows a random distribution of trifluoropropyl groups.

Conceivably, Dow Corning may now be hunting for a catalyst that will enable fluorosilicones to maintain the desirable stereospecific properties present in the intermediates. Aside from any academic interest for such a feat in catalysis, there would be highly profitable commercial uses for it.

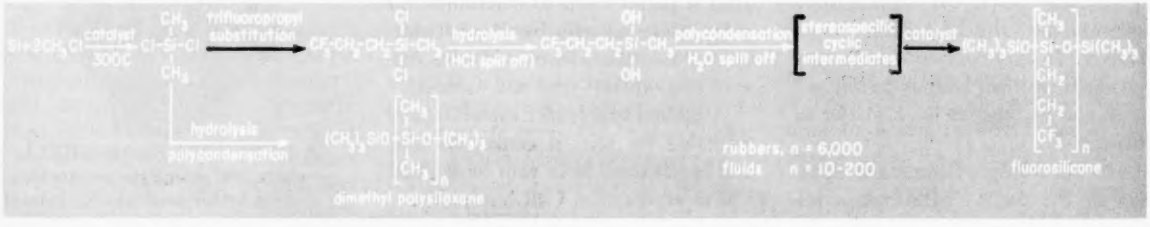
Be that as it may, the company believes that fluorosilicones will gain the same acceptance accorded silicones in the past decade.

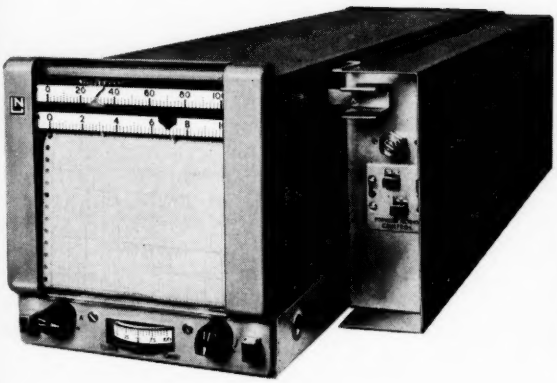
Another company, General Electric Co., has also altered ordinary silicones by grafting nitrile groups to the dimethyl polysiloxane structure (*Chem. Eng.*, June 12, p. 108), thus making new fluid compounds of greater solvent resistance and higher electrical conductivity. But whereas GE's nitrile silicones are still at the experimental stage, Dow Corning's fluorosilicones already are commercially available in five different grades (FS 1265 Fluid, FS 1280 and FS 1281 Compounds, and FS 1290 and FS 1291 Greases). These are all insoluble in water, most petroleum oils, fuels and solvents, except ketones and esters.

► **Fluids**—An eye-catching property of fluorosilicone fluids is their defoaming action in the presence of solvents (see photo). Both cylin-

* For more details on fluorosilicone rubbers, see *Chem. Eng.*, Aug. 10, 1959, p. 82.

Here is the route to fluorosilicones.





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LEEDS & NORTHRUP
Pioneers in Precision

ders contain equal amounts of a chlorinated hydrocarbon commonly used as dry-cleaning solvent. Air is bubbled through, and this solvent begins to foam. As little as 3 ppm. of fluorosilicone, added to the left cylinder, destroy the foam as soon as it is formed. Ordinary silicone defoamer, added to the other cylinder, has less resistance to the solvent and is less effective.

With molecular numbers ranging from about 20 to 200, FS 1265 is available at 250, 1,000 and 10,000 centistokes viscosity, although it can be supplied at other viscosities. Such fluids are inert and stable (from −40 to 400 F.) lubricants that can also be used as compressor oils, hydraulic fluids, and as plasticizers for rubbers and plastics. A rather specialized application is as substrate in gas or liquid chromatography. Here, the fluorosilicones have proved their effectiveness in steroid and alkaloid separations.

► **Permanent Lubricants** — Dow Corning has blended FS 1265 with inert silica filler. The resulting greaselike compounds (FS 1280 and FS 1281) have outlasted fluorocarbons when immersed in such corrosive media as fuming nitric acid, hydrogen peroxide and ethyl triamine. In indoor and outdoor lubrication of valves—such as plug valves—in lines handling solvents, oils and reactive chemicals, FS 1280 and 1281 might act as permanent lubricants, eliminating maintenance greasing. Their service temperature goes from −80 to 400 F.

The other two compounds, FS 1290 and 1291, are essentially fluorosilicone fluids thickened with lithium soap. They are unique because they provide solvent resistance, and can be used at the low temperatures that harden other solvent-resistant greases into brittle solids. These fluorosilicone greases are designed for lubricating all types of bearings that are exposed to splash, spray or vapors from corrosive chemicals.

► **Prices**—As they usually are at first, prices are high. FS 1265 sells at $25/lb. FS 1280 and 1281 for $35 to $40/lb. The greases, FS 1290 and 1291, are priced at $46/lb.

One comforting thought, however, is that the fluorinated rubber Silastic SL, which in 1956 sold at $30/lb., has dropped to $12/lb. The new fluorosilicones should also follow the same downward price trend.—**Dow Corning Corp., Midland, Mich.** **70A**

Waterproofing agent

Here's something for fall-out shelters.

With its new waterproofing agent for concrete, Guardian Chemical Corp. claims to have solved one of the major problems of building a fall-out shelter.

The company explains that the waterproofing agent prevents water from seeping into underground shelters. Carrying dissolved salts that become radioactive from the surrounding earth, this water can produce a dangerous level of radioactivity within the shelter.

Called Surtiseal the compound is a boron-silicon derivative. It can be applied by brushing, spraying or rolling on to concrete surfaces. Its protective action is reported to last longer than five years.—**Guardian Chemical Corp., Long Island, N. Y.** **72A**

Secondary amines

Organic intermediates entice host of specialty chemicals.

Five members of a new series of secondary amines are now available in development quantities. They are: N-(1-methylheptyl)-ethanolamine; N,N'-bis(1-methylheptyl)-ethylenediamine; N-secondary-butylaniline; bis(1-ethyl-3-methylpentyl)amine; and N,N'-bis(1-ethyl-3-methylpentyl) diethylene triamine.

As organic intermediates, these compounds can be used for preparation of unique amides, esters, fatty acid soaps, fungicides, bactericides, rubber chemicals and pharmaceuticals. Other possible applications are: cationic flotation agents, dispersants, emulsifiers, solubilizing agents, curing agents for epoxide resins, and cross-linkers for polyurethane foams.—**Universal Oil Products Co., Des Plaines, Ill.** **72B**

Fabric finish

Compound boosts fabrics' resistance to weather.

A new chemical agent, Arigal C, can eliminate the deterioration of fabrics that are in contact with the earth or exposed to humidity, rain, wind and sun.

Described as the first nonleaching, weatherproofing finish for continuous processing, Arigal C links itself to the fabric by chemical fixation. Application is simple, and elimination of an afterwash makes the use of this finish economical for both yarn and piece goods.

Its chemical composition has not been disclosed, but this agent differs from most weather-fast finishes

Newsworthy Chemicals

Page number is also reader service code number

Fluorosilicone polymers boast good solvent-resistance.....70A
Waterproofing agent cuts underground seepage.....72A
Secondary amines available for organic syntheses.....72B
Finishing compound for fabrics protects against weather.....72C
Phenolic resins give fast cure for foundry cores.....74A
Bleached Teflon yarn makes good packing for pumps, valves.....74B
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Polyethylene formulation has good properties for coating.....74F
Acrylamide-acrylic acid copolymer for pulp and paper industry.....74G

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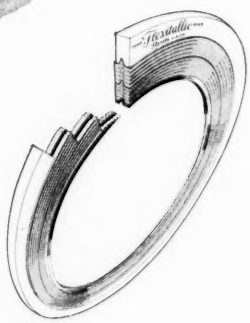

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SPIRAL-WOUND GASKETS

In designing today's jet aircraft, engineers rely on Flexitallic Gaskets to assure the safe transfer of highly volatile fuels from tanks to engines.

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because it does not affect the tensile strength of the fabric or cause shrinkage.

Recommended for treating cotton, viscose rayon and other natural cellulosic fibers (jute, rami, Manila hemp), Arigal C gives no bad odor during processing.

A control group of fibers and an Arigal-treated group were placed in a wooden frame and submerged in a river for 24 months. Untreated fabrics were completely disintegrated, but those treated with Arigal remained intact.—**Ciba Co., Inc., Fair Lawn, N. J.** 72C

Modified phenolics

New resins speed up curing of foundry cores.

New modified liquid phenolic resins and accelerators act as quick-setting core binders for high-volume, high-speed foundry operations.

The wet mix requires only resin, accelerator and sand, and can be prepared in any standard muller. In the hot-core box, cure time can be less than 15 sec. at 500 F., and will produce moisture-resistant cores of exceptional dimensional stability and high resistance to overcure. In production of both iron and nonferrous castings, the new core binders can give smooth casting surfaces.

This sand-resin-accelerator combination can produce only solid cores, except in specially contoured or mandrel-equipped core boxes. The small proportion of binder used, only 2% of total sand weight, frequently offers a saving in material cost. The core mix is usable for over 4 hr., depending on sand temperature.—**Durez Plastics Div., Hooker Chemical Corp., North Tonawanda, N. Y.** 74A

Teflon yarn

New bleached, preshrunk yarn improves shaft-packing service.

A bleached Teflon fiber has been developed for braided packing in pumps and valves. Tested extensively by several companies, this new packing material is much less sensitive to the effects of operational and frictional heat, and more receptive to gland adjustment, than the earlier unbleached fiber.

Improved performance is attributed to complete removal of all carbonaceous material from the Teflon fiber by bleaching and preshrinking it at 580 F. for 32 hr. prior to braiding. Carbon removal eliminates the sources of exothermic heat that results from oxidation of the carbon, and reduces the packing's tendency to burn. Preshrinking of the yarn before braiding gives greater stability at high temperatures so that the packing won't change dimensions during service.

Self-lubricating and chemically inert over a wide temperature range, the packing prolongs service life of high-speed rotary pumps and reduces special installation and break-in techniques.

The new yarn is priced at $18/lb. for 400 denier and $14/lb. for 1,200 denier.—**E. I. du Pont de Nemours & Co., Wilmington, Del.** 74B

Briefs

N-acetyl ethanolamine, now available in commercial quantities, is a plasticizer and conditioning agent for textiles, paper, cellophane and leather. It can also be used in printing inks, glues, and cork compositions. Because of its low toxicity, quantitatively equal to sucrose or glycerol, this new ethanolamine should be of particular interest in cosmetics and pharmaceuticals.—**Aceto Chemical Co., Inc., New York.** 74C

De-icing chemical, Ice Rem NC, can quickly melt ice and snow by lowering the freezing point of water to 11.5 F. It can be safely employed on ramps and walkways because it will not corrode iron, aluminum and magnesium, and has no effect on asphalt, concrete and rubber. Ice Rem NC has been used by airlines to protect landing gears from freezing.—**Palm & Patterson Inc., Cleveland.** 74D

New lubricants, specially formulated for fork-lift truck servicing, have been packed in aerosol spray cans. Hard-to-reach areas up to 5 ft. away can be reached with the spray. Two of the products, the fork-lift upright lubricant and the penetrating oil, contain molybdenum disulfide. The chain-and-cable lubricant contains graphite. These lubricants are part of a long-range program to reduce maintenance of fork trucks. — **Clark Equipment Co., Chicago.** 74E

Polyethylene, in a new formulation called Tenite 1H55P Natural, will produce glossy coatings that have a low friction coefficient. This plastic contains a special additive that is capable of withstanding the high (600 F.) melt temperature required in extrusion coating. Most slip additives usually volatilize or decompose at such high extrusion-coating temperatures. Among other desirable properties, this polyethylene has also uniform drawdown, low neck-in and edge variation, and good adhesion. — **Eastman Chemical Products Inc., New York.** 74F

A copolymer of acrylamide and acrylic acid, Mydel 550, improves dry strength and wet-end properties of paper products. It helps the retention of fibers and fillers on the paper machine. Particularly effective on board chemical pulps, Mydel shows a significant increase in burst and tensile strength, fold and pick. In mechanical pulp mixtures with a sulfite-groundwood ratio over 50%, the resin improves dry strength and cuts costs by allowing the substitution of more groundwood pulp for chemical pulps.—**The Dow Chemical Co., Midland, Mich.** 74G

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 165).

DICALITE®
TECHNICAL REPORT
DICALITE DEPARTMENT • GREAT LAKES CARBON CORPORATION • 612 SO. FLOWER ST., LOS ANGELES 17, CALIFORNIA

Unique Additive Filtration Discards Filtrate

Marty Harris, Dicalite engineer, reviews filtration procedure with A. H. Buck, plant manager, and R. C. Mosher, president of Barnett Laboratories.

The food additive carotene is widely used in margarine, shortening, bakery goods and pharmaceuticals where a natural yellow color and a high potency of vitamin A is desirable. A unique processing step, which might be called filtration in reverse, is employed by a leading producer of carotene—Barnett Laboratories, of Long Beach, California. Here, the liquid filtrate goes into cattle feed—and the valuable carotene is extracted from the filtered-out solids.

Barnett grows their own carrots ... a special variety yielding at least twice as much carotene as the ordinary table variety, and taking twice as long to grow. After the carrots are crushed, the carotene is washed out and the liquid goes to filtration. A Dorr-Oliver rotary vacuum precoat filter is used, starting with an inch-and-a-half precoat of Dicalite Special Speedflow Filteraid. The knife is set for a minimum cut to remove the deposited carotene material with the least possible amount of filteraid. This material is flash dried and air conveyed to the final steps of solvent extraction and crystallization.

Dicalite, while helping Barnett work out their filtration problems, was also able to assist them in designing the flash drying air conveyor system. Careful consideration of the total process is typical of Dicalite service. We'd be glad to work with you.

The solid crude carotene coming off the knife is the object of Barnett's filtration.

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Dicalite's "Man on the Spot"

M. B. Harris

When Marty Harris first consulted with Barnett, they were not satisfied with their filter operation. His first step was to take samples of the carotene liquid to the Dicalite products laboratory for study. Then a series of tests was made on a miniature rotary precoat filter. Harris worked closely with a Barnett representative and the Dicalite research men on this project. His recommendations to Barnett resulted in marked improvement in filtering efficiency. Today, after continued study and improvements worked out with Barnett, the firm is getting more than double the production per hour from the same filter.

Harris graduated from the University of Idaho with a Ch.E. degree, and worked for some time with American Potash & Chemical Corporation. For the first 2 years after joining Dicalite in 1945 he worked in the laboratory on research and customer service, before going into the field as District Manager, first in San Francisco and then in Philadelphia. He now serves Dicalite customers throughout the Southwest.

Marty is entitled to add P.E. after his name, for he holds a California State license as a Professional Chemical Engineer. He has contributed articles on filtration to publications in the petroleum, sugar and swimming pool fields, and is a member of the American Chemical Society, AIChE, Master Brewers Association of America, the American Institute of Sugar Beet Technologists and the Papermakers and Associates of Southern California.

TECHNICAL LITERATURE

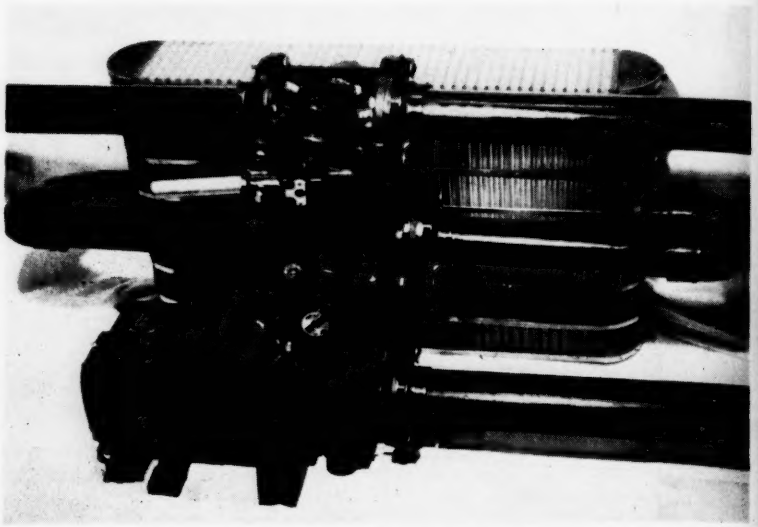
on Dicalite Filteraids is available on request. Bulletin B-14 discusses the principles and operating practices of filteraid filtration, and its applications in many industries.

Write for your copy to:

Dicalite Department
612 So. Flower Street
Los Angeles 17, California

REVERSIBLE FILTER CONQUERS HARD-TO-REMOVE CAKE

By frequent removal of thin cakes, a reversible-cake unit achieves high rates on slimes and slurries that are otherwise difficult to filter with reasonable efficiency.



Multiple-plate unit with 2-hp. pump can handle a maximum flow of 180 gpm. Plastic filter plates nest together snugly, need no gaskets.

To remove small amounts of filterable solids, try reversible-cake filtration. For feeds containing 0.01 to 1.0% solids, particularly those that produce thin, slimy cakes, the Granger filter has particular application.

Previously used largely for clarifying swimming pool waters, this filter process has been adopted for several industrial filtration jobs. The units are now available with injection-molded filter plates which, with their cost and corrosion-resistance advantages, may make the filter more appealing for additional applications.

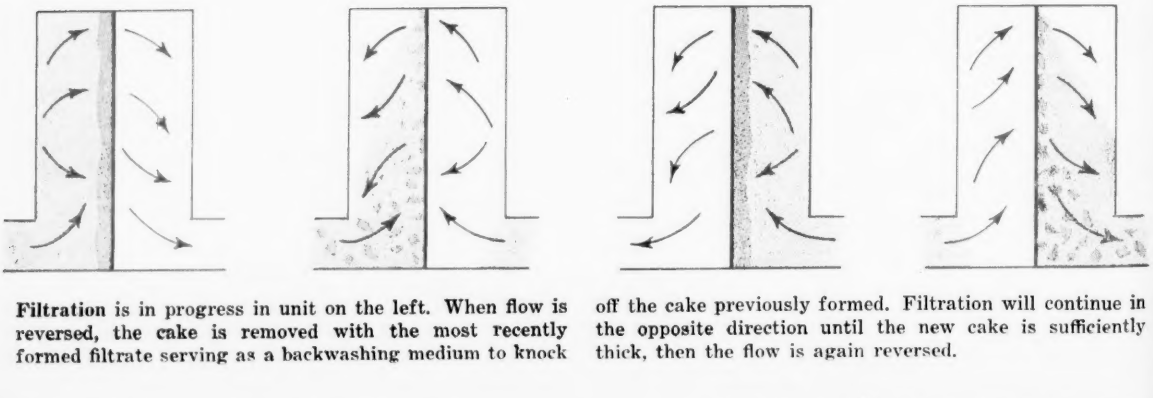
The principle of reversible-cake filtration is simple. Feed is directed through the filtering medium in one direction until cake thickness affects filtration rate. The flow is then reversed with feed flowing in from the opposite side of the filtering medium.

▶ **Self-Plugging Backwash**—Upon reversing, the cake already established on one side of the filter is washed off. And it is in this step that the particular advantage of the reversible unit is demonstrated.

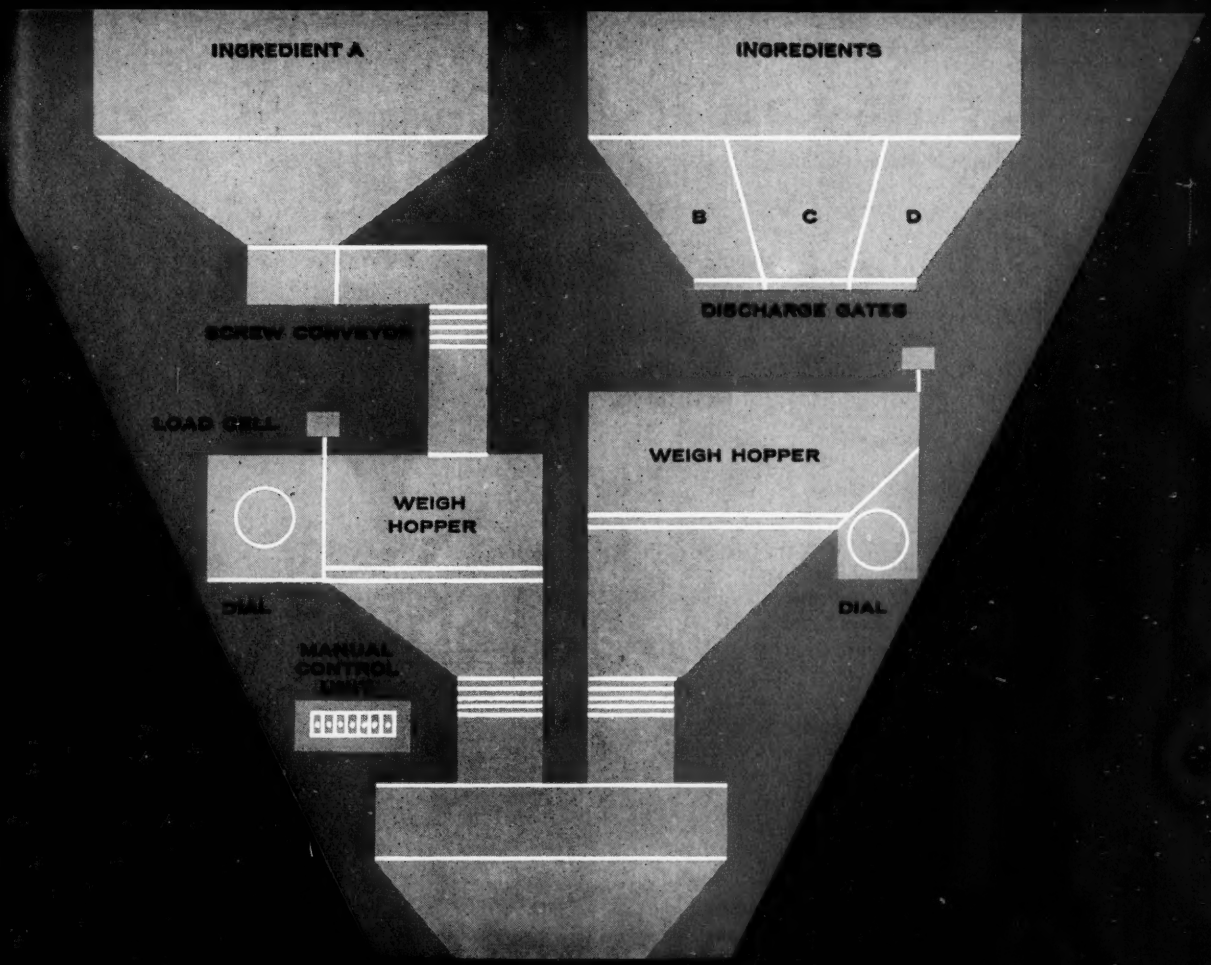
In conventional filtration, the backwashing operation is sometimes plagued by a cake that is not readily removed by the first flush of backwash liquid. If part of the cake sloughs off at once, the majority of the liquid then flows through the open space, reducing the pressure drop that is needed to remove the more stubborn portions of the cake.

In the Granger unit, however, instead of backwashing with a clear fluid, a plugging fluid (feed) is used. If only part of the cake breaks away, the concentration of flow through that area builds up some cake on the reverse side of the filter medium, creating a pressure drop and forcing a redistribution of the washing liquid, so as to carry off the balance of the cake still clinging to the other side.

▶ **High Filtration Rates**—By discharging thin and slimy cakes auto-



Filtration is in progress in unit on the left. When flow is reversed, the cake is removed with the most recently formed filtrate serving as a backwashing medium to knock off the cake previously formed. Filtration will continue in the opposite direction until the new cake is sufficiently thick, then the flow is again reversed.



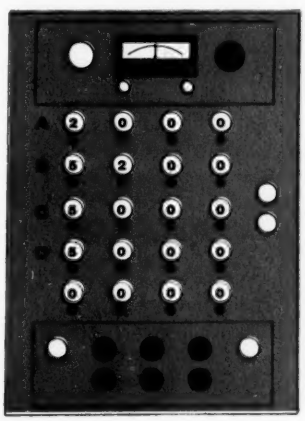
TIME SAVER... MONEY SAVER...

THE NEW FAIRBANKS-MORSE BATCHETRON

One of the latest developments in Fairbanks, Morse's 131 year experience in the weighing business is the *new* Batchetron. It is specifically designed for fast, accurate proportioning of any material that can be pushed, poured or dropped into weigh hoppers. It uses high-speed electronic methods to weigh and batch a number of liquids or solids—in sequence or simultaneously—by means of manual or punched card control.

The Batchetron is easy to set. Its high-speed action assures positive cutoff of ingredient flow. Interlocks prevent incorrect operation . . . halt operation if anything goes wrong. An improved, electronic weight-sensing system provides long, accurate, trouble-free service with exact batch repeatability every time. At all times control of operations is lightning fast.

The control panel of the Batchetron allows the operator to adjust for hopper tare weights, while pilot lights indicate batching startup, sequence and finish.



Use of the F-M Batchetron results in substantial time and money savings for the chemical and food industries . . . for concrete and asphalt batching plants . . . for the many applications where high-speed weighing and proportioning are important. And, of course, the many years of Fairbanks-Morse precision craftsmanship stand behind every Batchetron.

Learn what the Batchetron can do to make *your* operations more profitable.

Write: Fairbanks, Morse & Co.; Electronics Division; 100 Electra Lane, East Station; Yonkers, New York

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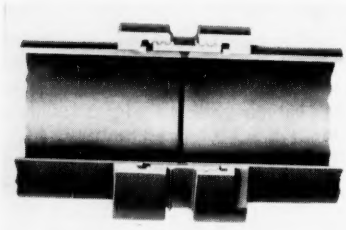
matically in this way, the unit can attain the high flow rates associated with thin cakes. The length of time required to clean the old cake and start producing clear filtrate can be determined by observation, then set on a time cycle. It usually takes from 20 sec. to 2 min.

Obviously, all cake is discharged as a wet slurry, containing part of the clear filtrate. For complete recovery of dry cake and all the filtrate, an additional thickening and filtration step is needed.

In comparison with fixed-leaf filters, the Granger unit requires less recycling of dirty filtrate associated with cake formation. Where fresh cake is being established in any filter, there is always some initial bleeding through the filter medium, and filtrate has to be recycled until bridging on the cloth is accomplished. In reversible filtration, initial bleeding occurs during backwash.

Injection-molded filter plates have been produced with close tolerances, so that without gaskets, filters containing up to 63 cloths have been made without leaks. No metal is in contact with the fluid being filtered; any filtering medium in a thin sheet form can be used. The plates are designed for 150 psi. at room temperature.—**Granger Filter Co., Wakefield, Mass.** **76A**



Pipe, tube coupling

Union device permits quick making and breaking of connections.

Metal and plastic pipe and tubing are joined by this coupling that acts as a union and shortens time of making and breaking connections.

The unit consists of a cylindrical connector piece into which the tubing ends fit, and two nuts that draw the ends against a gasket. The connector piece acts as a bearing surface and assures proper alignment. Only the gasket is in contact with material flowing through the coupling.

Connections are made with a single tool that trues, bevels and grooves the two pipe ends. A ring snaps into each groove to provide a gripping point for the nuts. Size range is ½-6 in., with gaskets of neoprene or Teflon. All-stainless-steel units are available for special applications. — **Cooper Alloy Corp., Hillside, N. J.** **78A**

Melting kettle

Close temperature control possible with cylindrical melting tank.

Organic or inorganic materials that melt between 300 and 600 F. may be melted in a new kettle that is cylindrically shaped, with heat applied uniformly around the sides as well as on the bottom.

Adjustable automatic controls hold the contents within ±5 F. of any temperature within the range. An agitator is available for manual or mechanical mixing, and an electrically heated quick-acting lever valve helps to hold the material at proper temperature, right up to final pouring.

Kettle comes in capacities from 90 to 5,800 lb.—**Trent, Inc., Philadelphia.** **78B**

Kettle agitator

For tough mixing jobs, three different agitators work together.

Heat transfer and mixing are enhanced in steam-jacketed kettles with a unit that utilizes three agitators working together. One or two of the latter may be removed for products that require only stirring action. Kettles are available for steam pressures of 40, 90 and 125 psi.

In operation, a primary anchor-type agitator scrapes the heated portion of the kettle wall, shoveling the product into the path of the higher speed secondary agitators. These mix the product and keep it in suspension without allowing dead spots to form around the primary agitator shaft.

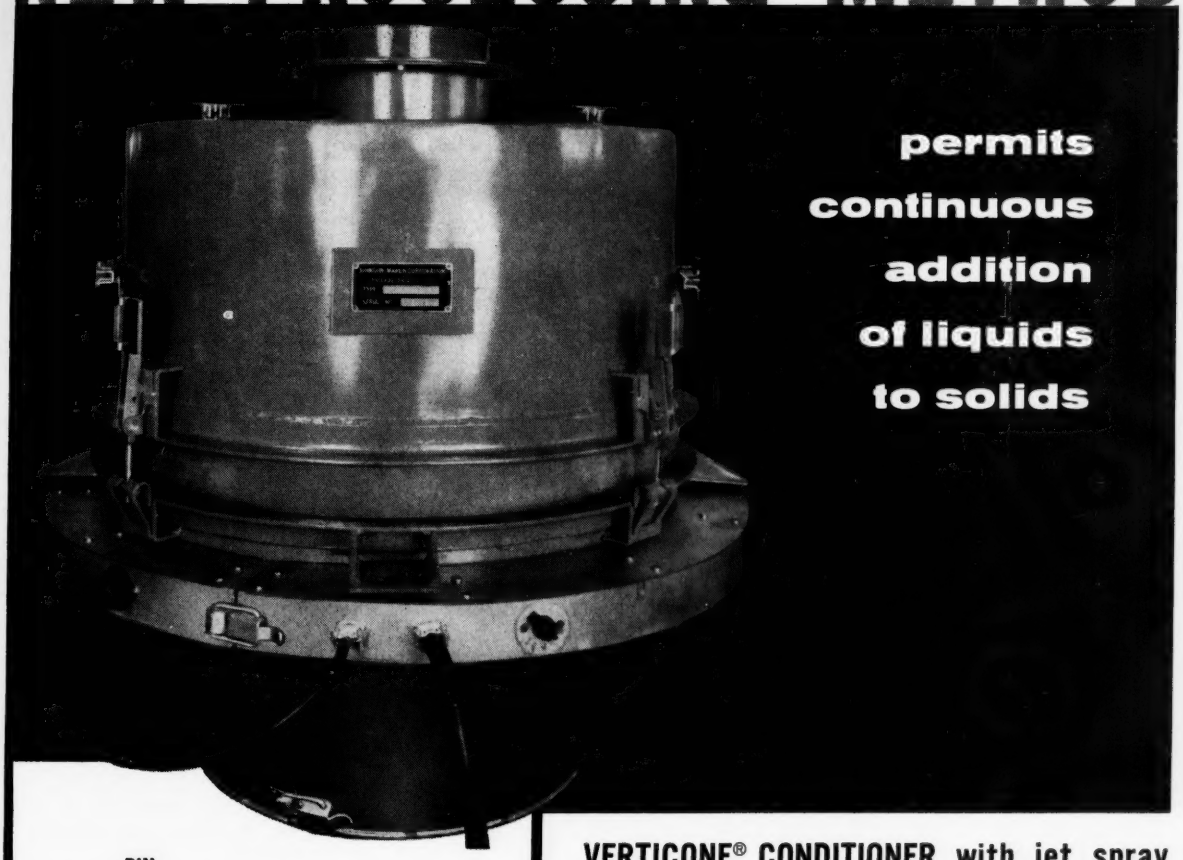
Four types of secondary agitators are available for blending, mixing or beating. The unit is designed to prevent possible contamination of the batch from overhead lubrication leakage.—**Hamilton Kettles Div., Brighton Corp., Cincinnati.** **78C**

Instrument valve

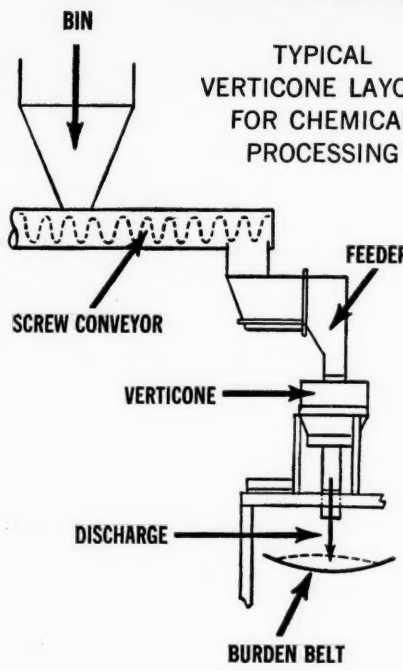
Three-position unit simplifies gage installation and maintenance.

Pressure gages that require a bleed line are quickly installed and easily maintained with a three-position valve containing Teflon sleeves. Rated for 300 lb. ASA, the valve serves at tempera-

NEW PROCESSING METHOD



permits continuous addition of liquids to solids



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tures from −50 to +400 F., with corrosive or noncorrosive gas or liquids.

With a 180-deg. turn of the handle, the valve can provide gage reading, gage cut-off, and gage bleed or calibration. Available in bronze or stainless steel, the unit comes in ¼, ⅜ and ½-in. sizes, all with ½-in. screw ends.—**Continental Mfg. Co., New York.** **78D**

Polyethylene jug

Recessed handle admits gloved hand, facilitates pouring.

This 5-gal. jug handles easily because of the curved handle, with plenty of space to insert even a gloved hand. The recessed design also permits use of an overpack with the conventional polyethylene model, as approved by the ICC.

The 3½-lb. unit is also available in linear polyethylene for use without an overpack. Ultraviolet inhibitors are used in both models. —**Owens Plastics Co., Kansas City, Mo.** **80A**

For more information about any item in this department, circle its code number on the Reader Service Postcard (Page 165).

Level controller

Segmented radiation device provides continuous indication, control.

Correct liquid levels can be maintained with a radiation-type controller that can be applied to almost any size of vessel, according to the manufacturer. Sensing heads housed in thick steel tubes meet explosion-proofing requirements.

Thermally stable between −60 and +150 F., the device has no moving parts. Its sensing equipment never comes in contact with the material being measured, hence material viscosity cannot affect the reading. Recording and other instruments may be located as far as 500 ft. from the controller.

A 4½-in. indicating meter, graduated from 0 to 100, is housed in a welded steel cabinet, with a gasketed door to retard entry of dust or harmful vapors. Heads are 6-in. long, may be increased in similar increments to meet specific applications.—**The Ohmart Corp., Cincinnati.** **80B**

Level indicator

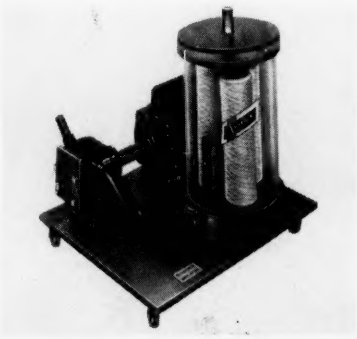
Liquids of 0.7 to 1.1 sp. gr. are measured by displacement.

Liquid level is measured and converted directly to an electrical resistance in a new level indicator. The signal generated may be used for remote level indication, alarm, recording or control, or for tie-in to computer systems.

A frictionless magnetic coupling transmits motion from level changes in the vessel to a contact wiper movement on a potentiometer winding mounted inside the housing.

In operation, a change in level is sensed by a displacer suspended in the liquid by a precision expansion spring, causing the spring to extend or contract. A ball attached to the displacer by a stem is centered inside a non-magnetic pressure-tight tube; as the ball moves up and down, a pivoted horseshoe magnet on the outside of the enclosing tube follows the ball and transmits movement to the contact wiper.

Displacers of various length are available to measure a wide range of level changes. The instrument is adjustable to allow operation with liquid of different specific gravities.—**Magnetrol, Inc., Downers Grove, Ill.** **80C**



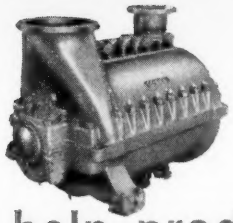
All-plastic filter

Various corrosion-resistant materials are used in construction.

No metal contacts the solution in this unit designed to filter extremely corrosive, expensive and sensitive liquids. Lucite, epoxy resins, Teflon, neoprene, Hypalon and Kel-F are used for the pump and filter chamber, as required by the fluids handled.

The standard model has a full-view Lucite filter chamber, can filter 100 gph. Other models handle from 25 to 1,200 gph. Dynel or cotton filter tubes with polypropylene are used to remove particles down to 1 micron; for

New Equipment continues on page 154



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The job is producing acrylonitrile from natural gas . . . and sixteen Clark centrifugal compressors play a vital role in getting it done. Installed at the Fortier, La. plant of American Cyanamid Company, they have been in continuous service since startup.

Shown above is a battery of seven Clark units handling air in the main compressor building. Elsewhere in the plant, Clark centrifugals are compressing hydrocarbon gases and nitrogen for other phases of the process.

In addition to unusual reliability, several important operating characteristics of Clark compressors influenced American Cyanamid's choice: Their design permits diaphragm or injection cooling for temperature control and greater safety. Dependable, adequate sealing systems have been developed and are available for specific requirements. Integrally supported bearings minimize the bearing span, permit the use of a greater number of impellers, and assure permanent alignment.

Highly regarded in the expanding petrochemical industries, proven Clark centrifugal compressors are operating in a wide range of processes throughout the world. They are at work in ethylene, acetylene and butadiene plants, as well as numerous other applications which require gas compression, air compression, low temperature refrigeration, vacuum, and other services.

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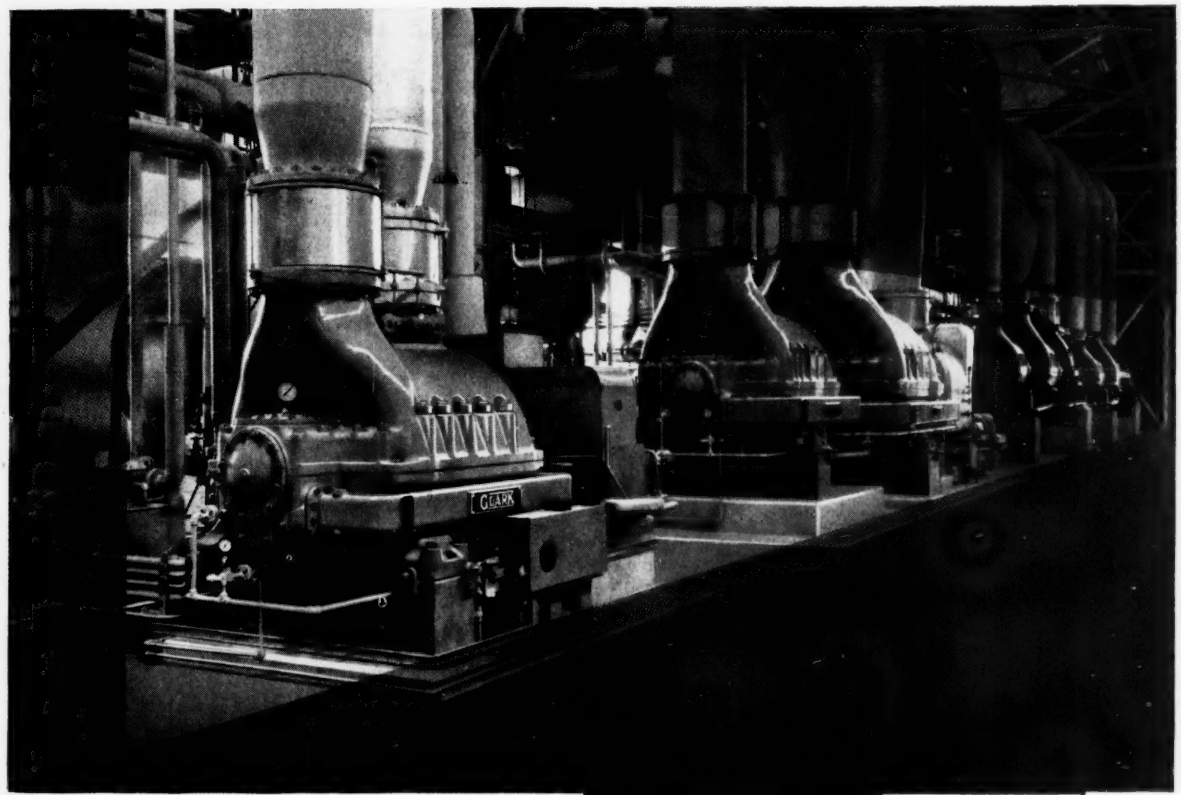

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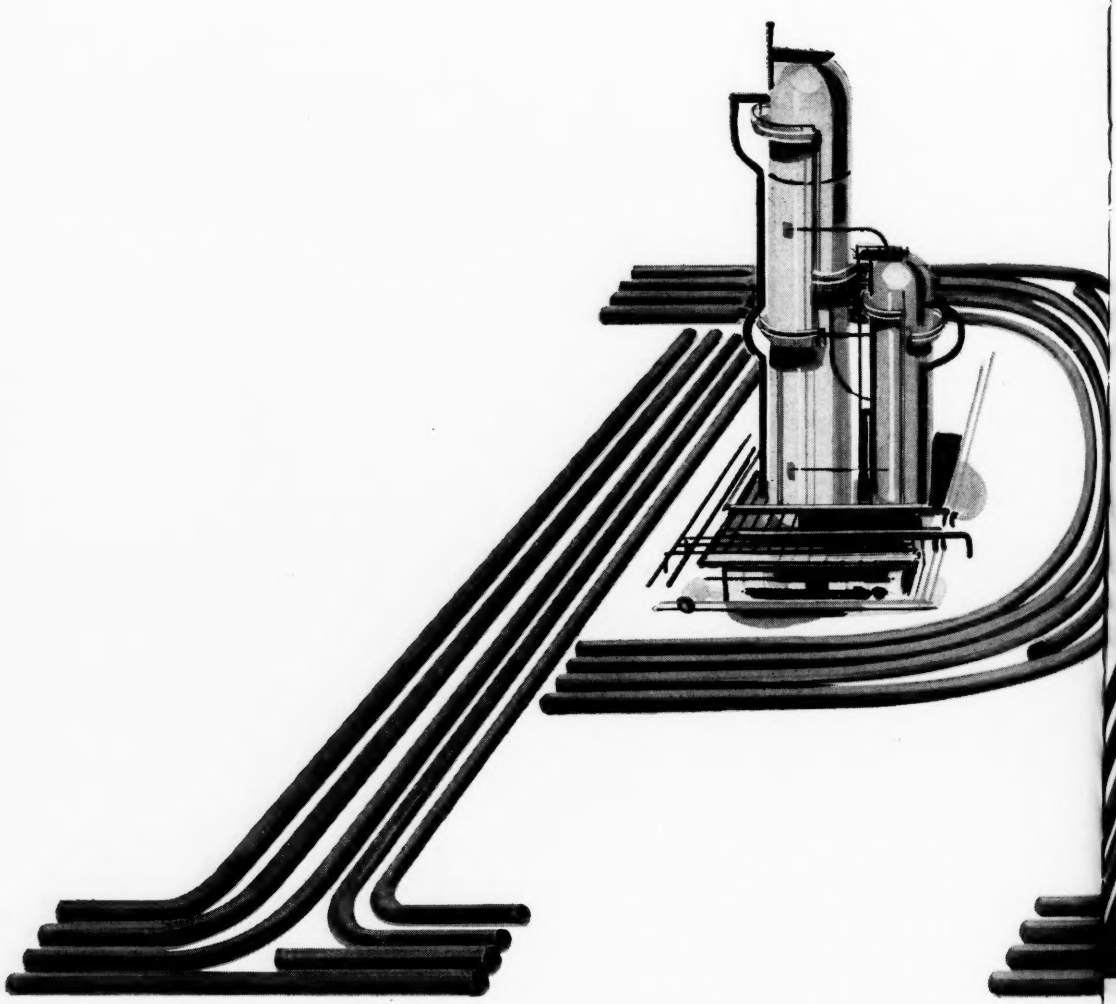

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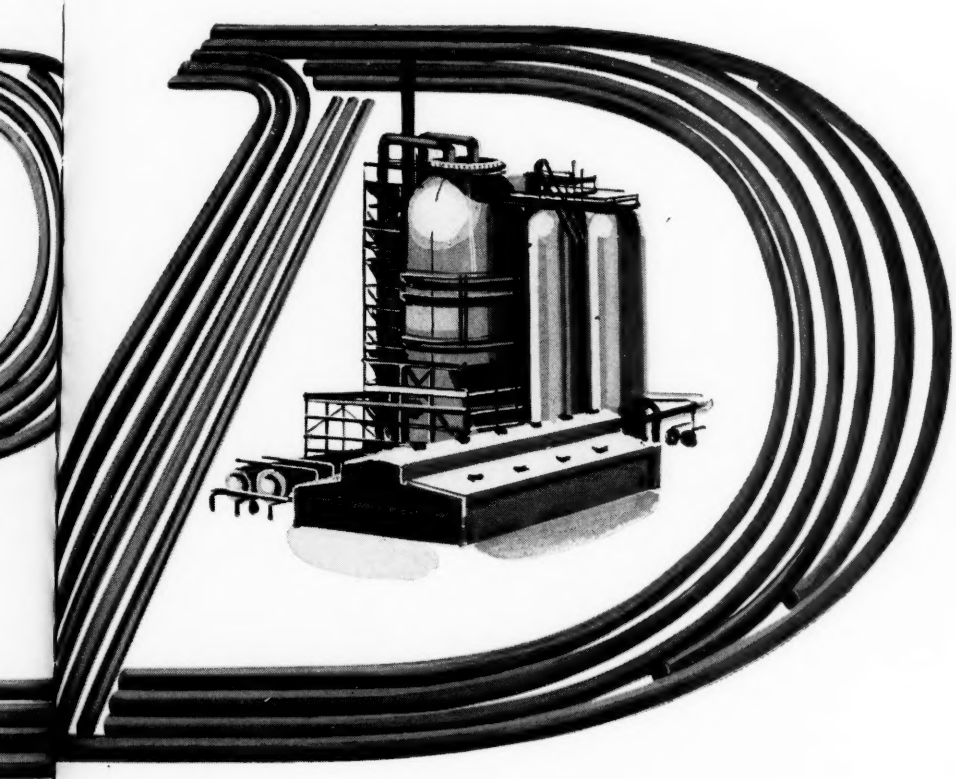

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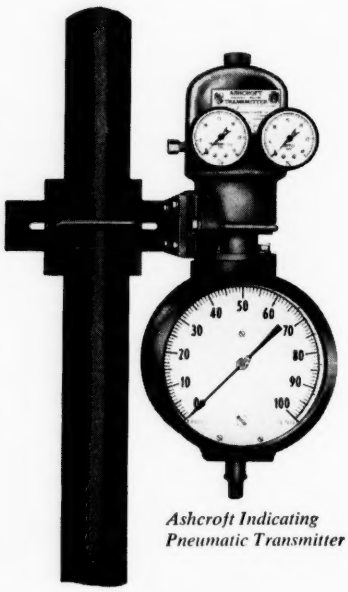

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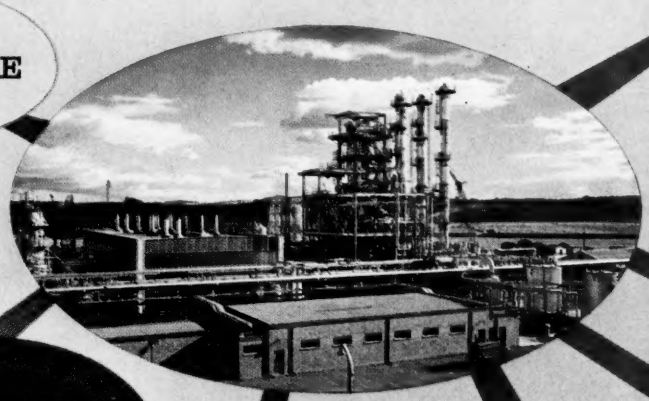

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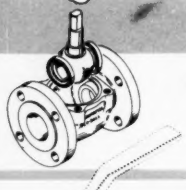

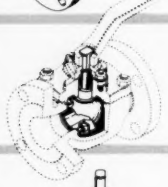

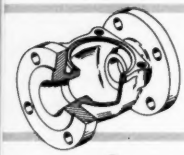

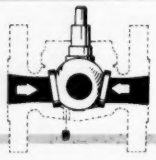

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1. TOP ENTRY All internal parts can be removed and re-installed without removing valve from line.	√			√		
2. TOP AND BOTTOM GUIDED BALL Provides truly double seal, extends seat life. Makes for easy operation.	√					
3. DOUBLE SEATS Interchangeable and replaceable seats insure sealing in both directions; give double protection against leakage.	√	√	√	√	√	√
4. FLANGES INTEGRAL WITH BODY Rugged, one-piece body design gives greatest possible strength.	√	√		√		
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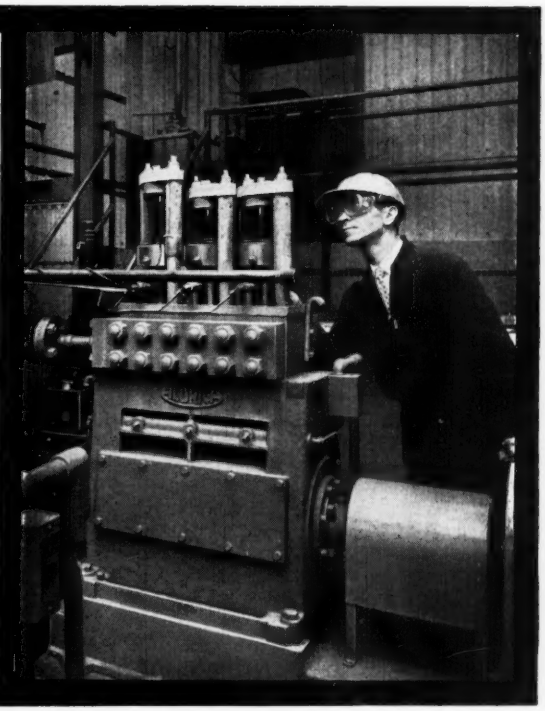
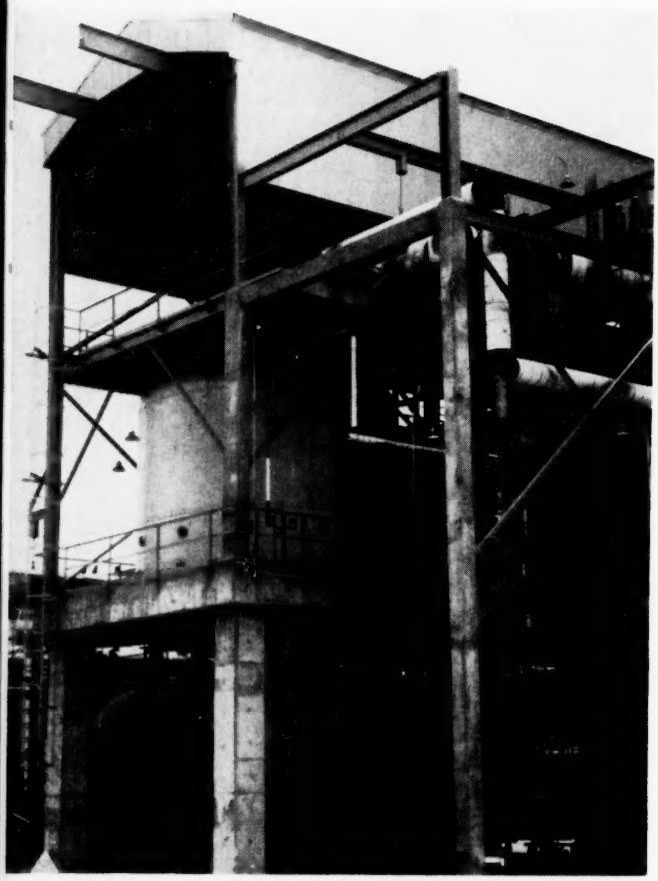


Process Flowsheet

New Catalyst for Butadiene Unit

Copolymer Rubber & Chemical Corp. is operating a new process in its expanded butadiene plant at Baton Rouge, La. Key feature: a catalyst that boasts both high conversion and good selectivity.

T. H. ARNOLD, JR.
Southwestern Editor



Reactor, one of two, houses dehydrogenation reaction.

With the completion of a program to increase its butadiene capacity at Baton Rouge, La., by 50%, Copolymer Rubber & Chemical Corp. has become the second U.S. firm to use Dow Chemical Co.'s catalyst process in making this synthetic-rubber component.

Copolymer claims that the new process, which is built around use of a calcium-nickel-phosphate catalyst, has upped butadiene yield per pound of butylene feedstock. Plant feeds a 90% butylene stream and achieves a conversion level around 40%, with selectivity around 85-90%. (One feature of Dow's catalyst: selectivity is essentially constant at conversions below 40%.)

During its $5-million expansion, the company made several major equipment changes in order to use the new catalyst. Main addition was two identical, parallel-operated dehydrogenation reactors, each with a waste-heat boiler. In the Dow process, butylene feed is heavily diluted with steam, and steam is also used during reactor regeneration; accordingly, Copolymer put in a new boiler plus a 180,000-lb./hr. steam superheater. Other new equipment includes a six-unit air condenser and an absorber-stripper combination to remove byproduct carbonyls.

First U.S. user of Dow's route was Neches Butane Products Co., Port Neches, Tex. Two plants outside the country also employ the process: one at Fawley, England, the other at Sarnia, Canada.

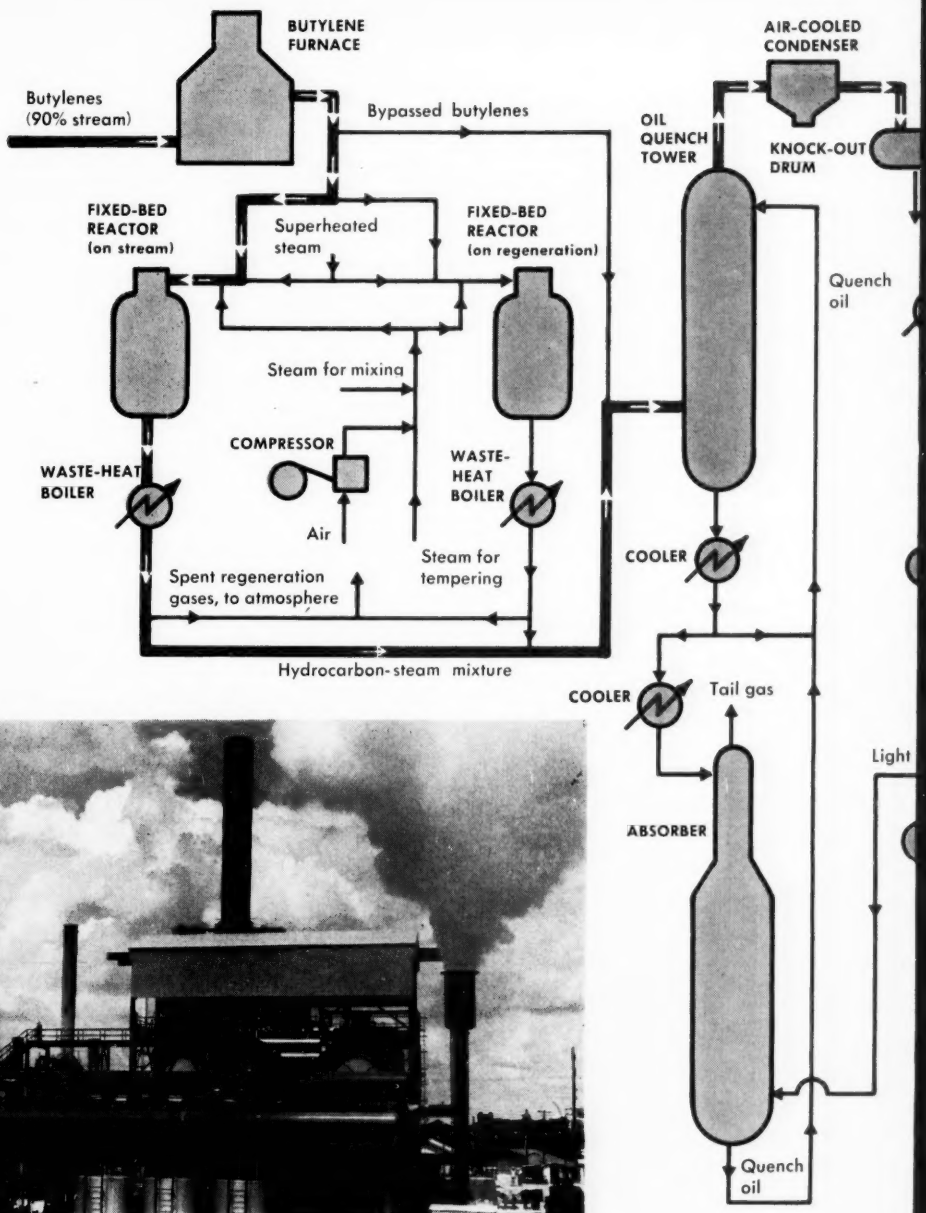
▶ **Reactors**—Butylene feedstream from petroleum refining operations is purified to remove acid esters and then sent to dehydrogenation feed storage. Then, it passes to the reactors, undergoing heating and dilution by superheated steam.

The catalyst is used in the form of cylindrical pellets in a fixed bed. Good service life for this material depends greatly on the completeness of carbon burn-off during regeneration. To avoid excessive coke deposits in the first place, a high steam-dilution ratio of 20 to 1 is used during reaction, and the reaction time is kept short.

The reactors operate cyclically: one is on stream while the other is being regenerated. A series of preset electrical timers controls the cycle, and the system incorporates interlocking safety relays to insure against improper valve switches.

In the regeneration sequence, tempering

Unfold flowsheet

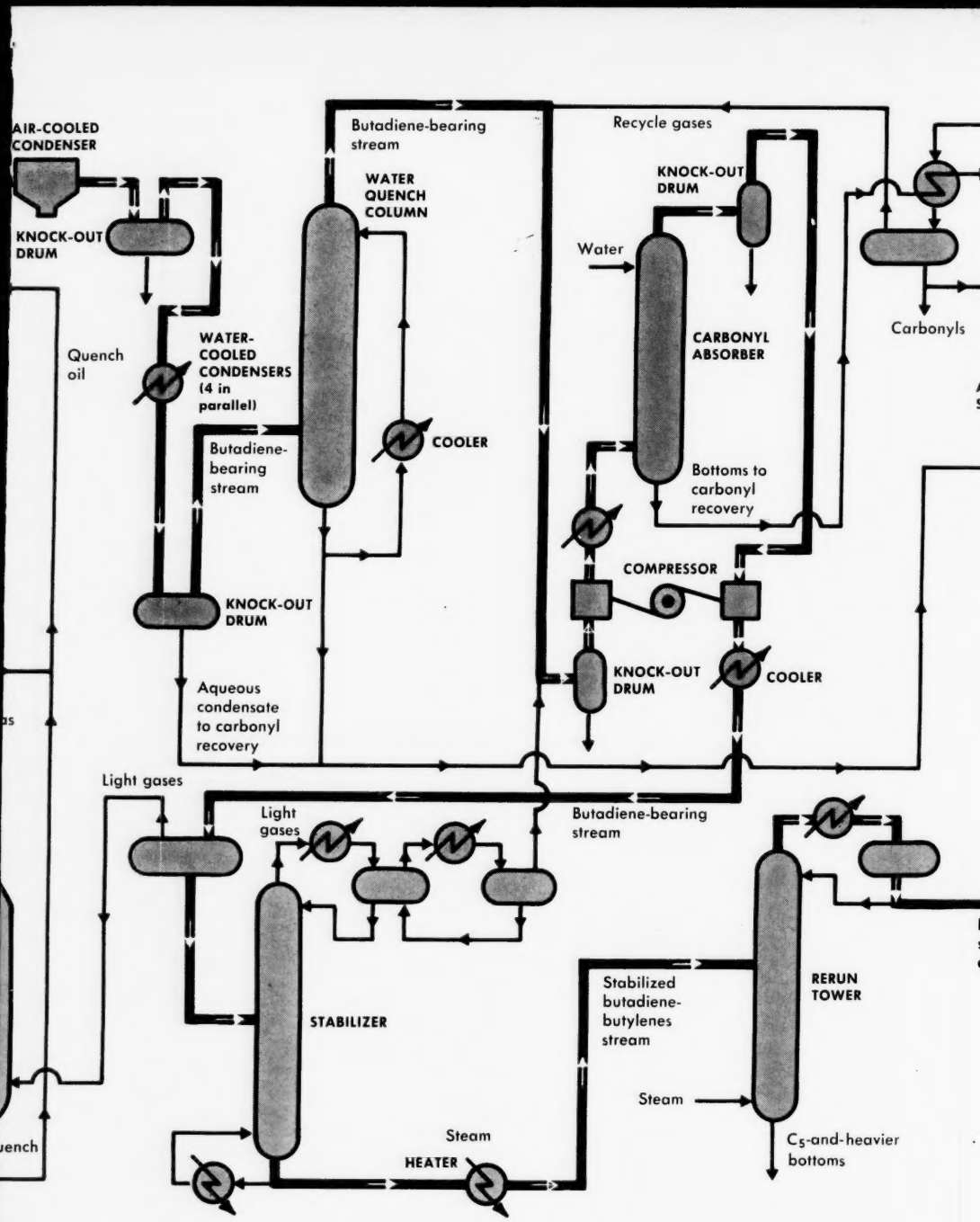


New butadiene unit was designed and constructed by Foster Wheeler Corp., New York.

steam first purges the reactor. Then, a mixture of steam and air passes through the vessel to accomplish the actual regeneration. Carbon burns off almost immediately—Copolymer reports that carbon dioxide content of the effluent gases drops back to zero after three minutes of regeneration.

Each complete cycle is about 30 minutes. During valve switching, butylene bypasses the reactors for approximately 14 seconds.

▶ **Downstream**—Effluent streams give up heat in waste-heat boilers. Spent regeneration gases vent to the atmosphere, while the product from the on-stream reactor goes to an oil-quench tower for cooling. The steam in this mixture then condenses in a six-unit air condenser followed by water-cooled condensers. Condensate is separated in a knock-out drum, and the gaseous butadiene-rich stream cools further in a water-quench column. Bottoms from this column, as well as the condensate, go to a stripper that steam-strips carbonyls.



gases vent
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carbonyls.

Meanwhile, the overhead product stream from water quenching is compressed in two stages. Between the first and second stages is a water-scrubbing operation that removes carbonyls, which are subsequently recovered in the stripper.

Compressed stream is cooled, and the partially liquefied mixture passes successively through a separator drum and a stabilizer, which take out C_3's and lighter gases. Part of the light stream recycles to compression; part countercurrently rises against the quench that vents tail gas overhead.

Stabilized butadiene mixtu
tower that separates C_5-and-hea
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shown above) where cuprous a
is used to complete the butadie

Unreacted butylenes are s
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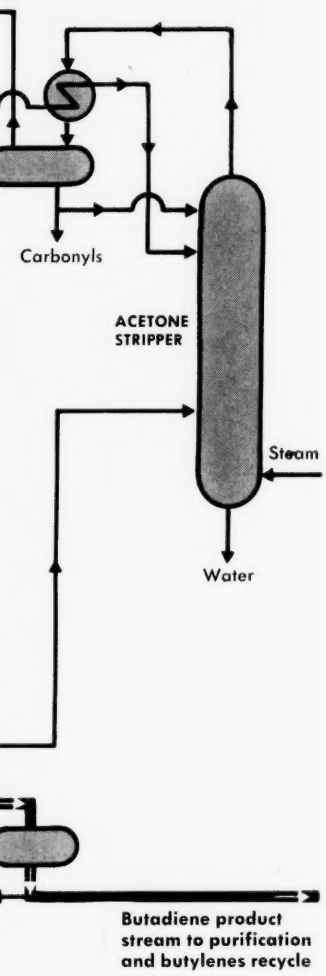

avier

the quench oil in an absorber
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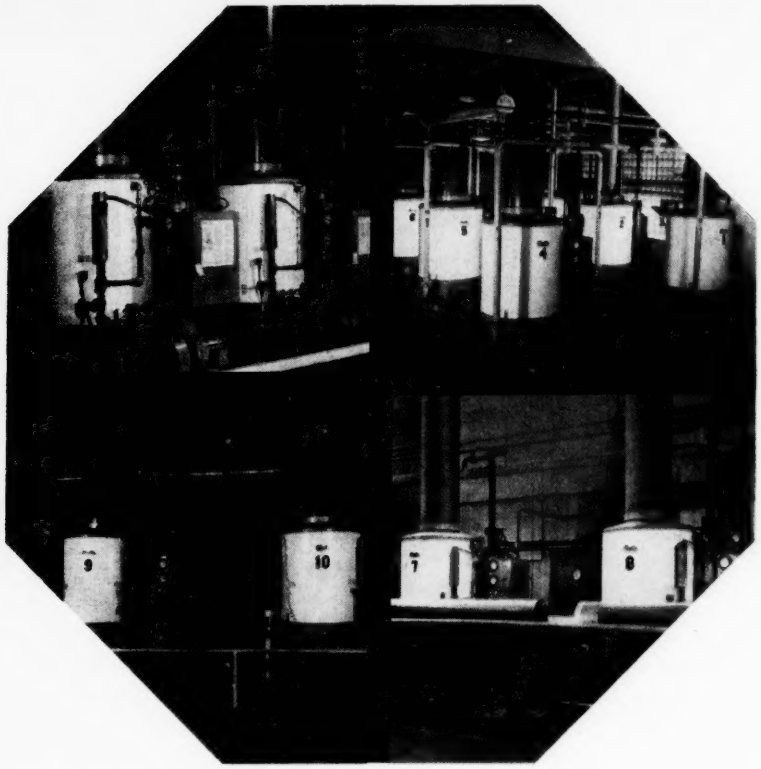

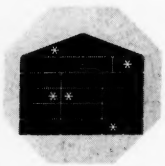

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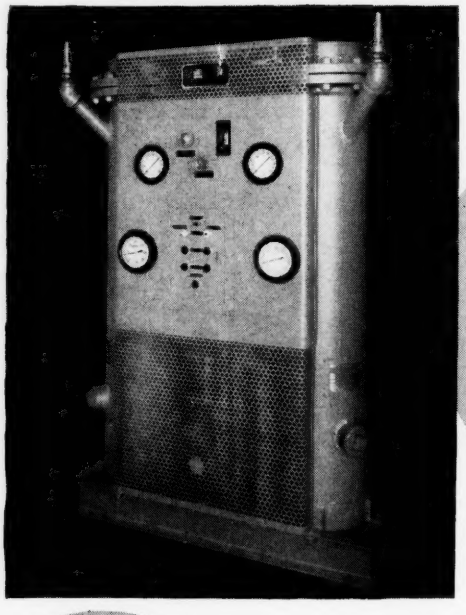

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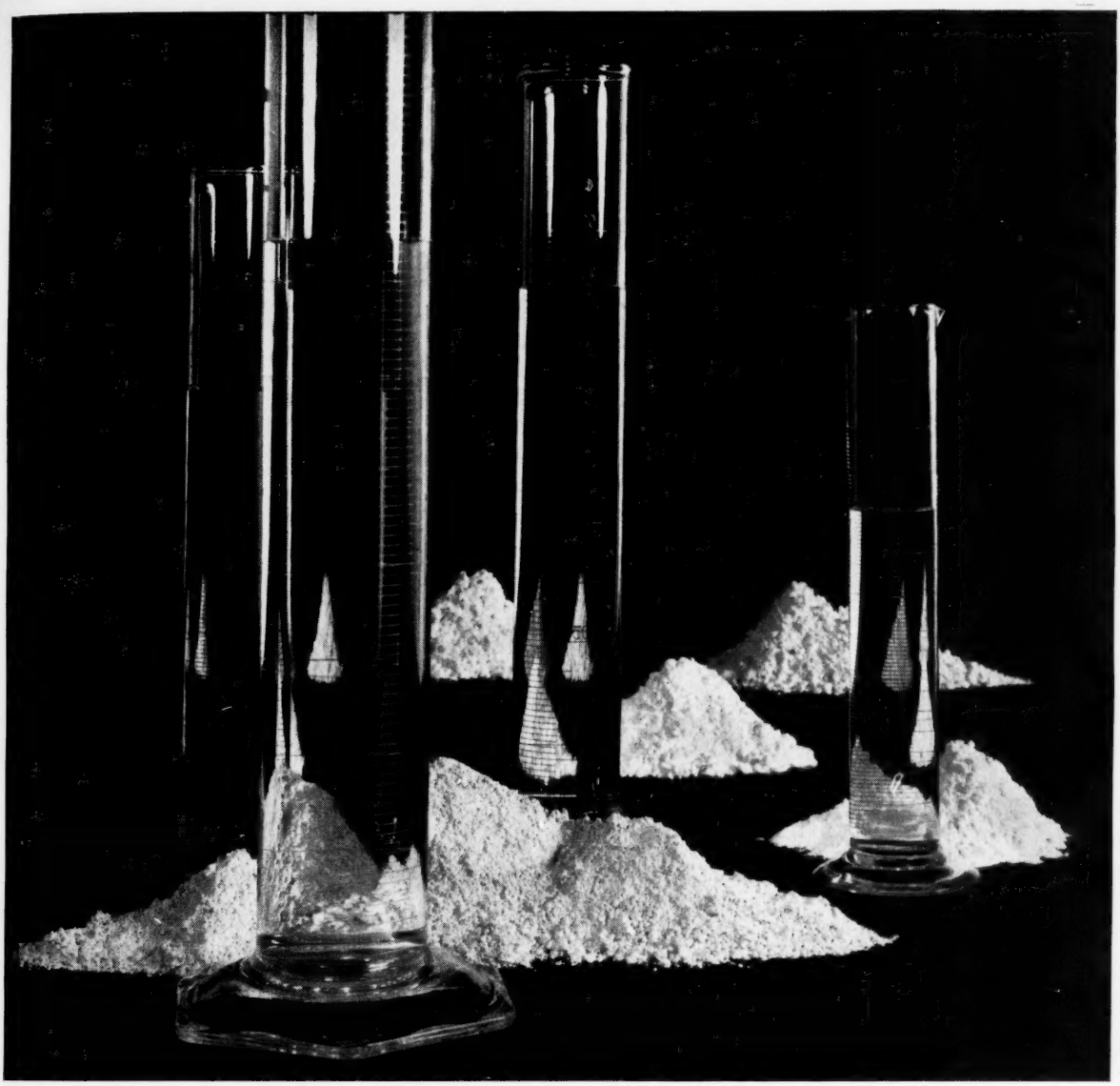

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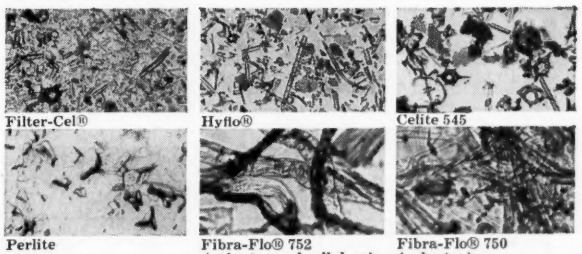

These photomicrographs show the range of characteristics available with Celite filter aids. 100μ

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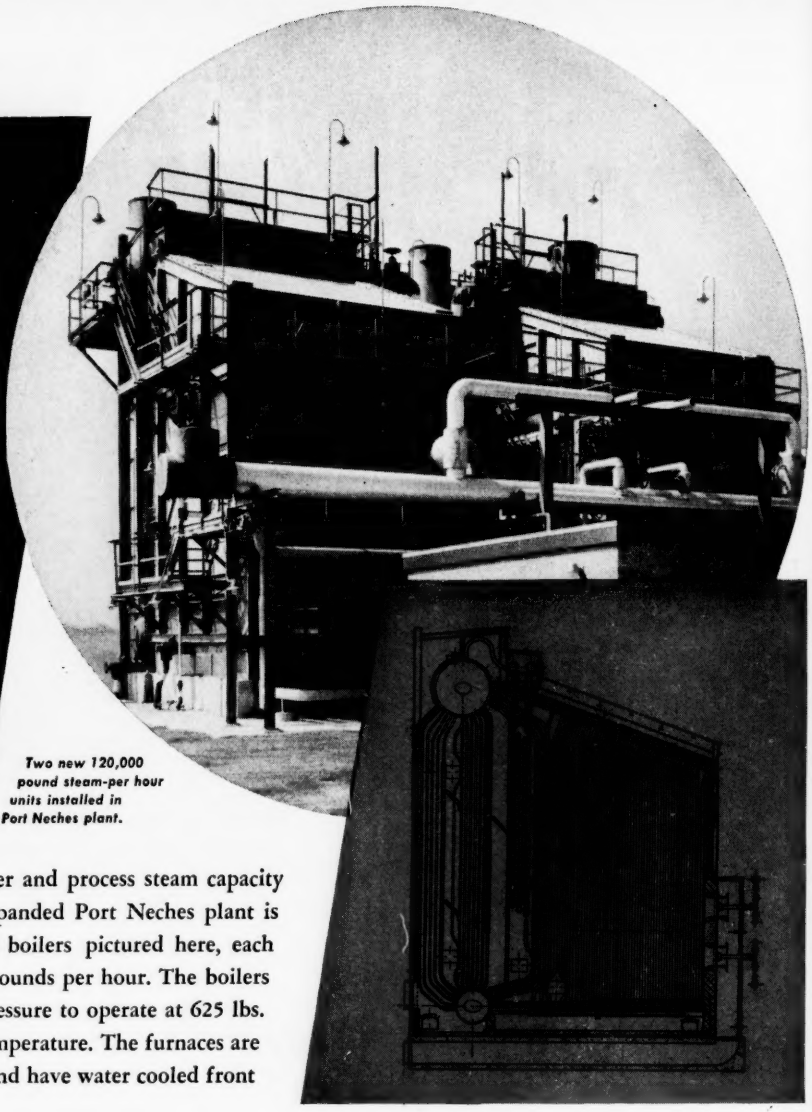
Steam for Jefferson Chemical by Vogt

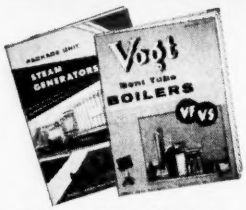


Two new 120,000 pound steam-per hour units installed in Port Neches plant.

The needed additional power and process steam capacity for Jefferson Chemical's expanded Port Neches plant is furnished by the two Vogt boilers pictured here, each with a capacity of 120,000 pounds per hour. The boilers are designed for 675 lbs. pressure to operate at 625 lbs. pressure and 769°F. total temperature. The furnaces are equipped with gas burners and have water cooled front and side walls.

Bulletins describing Vogt boiler installations in a variety of industrial plants for power, processing and heating are available on request.

Installation by C. F. Braun and Co., Engineers.



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STEAM GENERATORS

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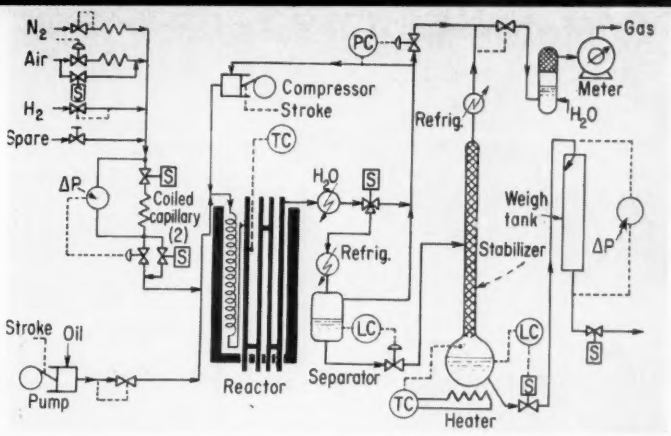
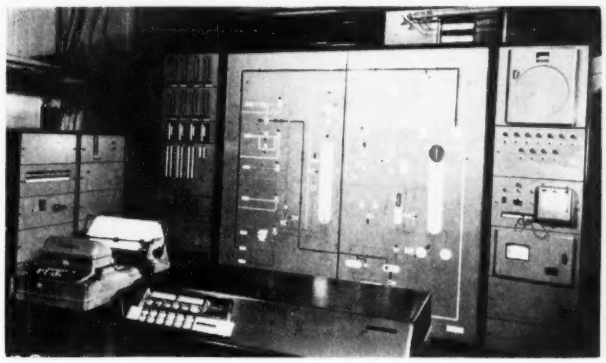
Process Evaluation in Computer-Run Microplant. . .



. . . a unique unit for process industries (below). Flowsheet of plant (above) sketches task.

C. W. DOWDING, *Consolidated Systems Corp.**
F. R. RUSSELL, *Esso Research & Engineering Co.*



We deal here with the first completely automated, computer-controlled pilot plant built for a process company. Presented are the justification for such a unit, discussion of problems encountered in its design, solutions adopted for these problems, and results obtained with the unit.

Esso has purchased an automatic computer-controlled pilot plant, built for it by Consolidated Systems Corp., to evaluate processes that use solid catalysts. The unit was built to operate safely unattended, except for periodic servicing. It is designed to:

1. Measure, control and periodically print out averages of all pertinent operating variables.
2. Print out, at the end of each hourly period, any conditions that were outside desired limits and the time when they strayed.
3. Analyze products to follow the reaction.
4. Calculate, correct and print out results for each hourly period, and summarize data for all periods making up a run.

This unit, initially being used for evaluation of the hydroforming process, demonstrates the advantages of such an automatically controlled unit over standard procedures for relatively stable test programs.

- Improved test accuracy from closer control, more-frequent data sampling and correction, and fewer calculation errors.
- Better test supervision and quicker alarms.
- Shorter runs and programs.
- Faster decisions for further work because of quicker test results.

An important intangible advantage is that the quicker results and shorter test program might cut lead time for a new plant or process improvement. Another is that it exposes some of the problems likely to be encountered in automation of full-scale equipment.

Savings predicted to justify purchase of the automatic pilot plant (see Table I) depend as much on improved accuracy as on any other item. The importance of improved accuracy stems from the large decrease in number of runs required in most programs for a small accuracy improvement. A 30% improvement in accuracy statistically halves the runs required.

Shown in Table I, the savings include both professional and nonprofessional personnel. Against these savings are capital costs and a higher maintenance cost, including at least a part-time electronic technician.

A Straightforward Process

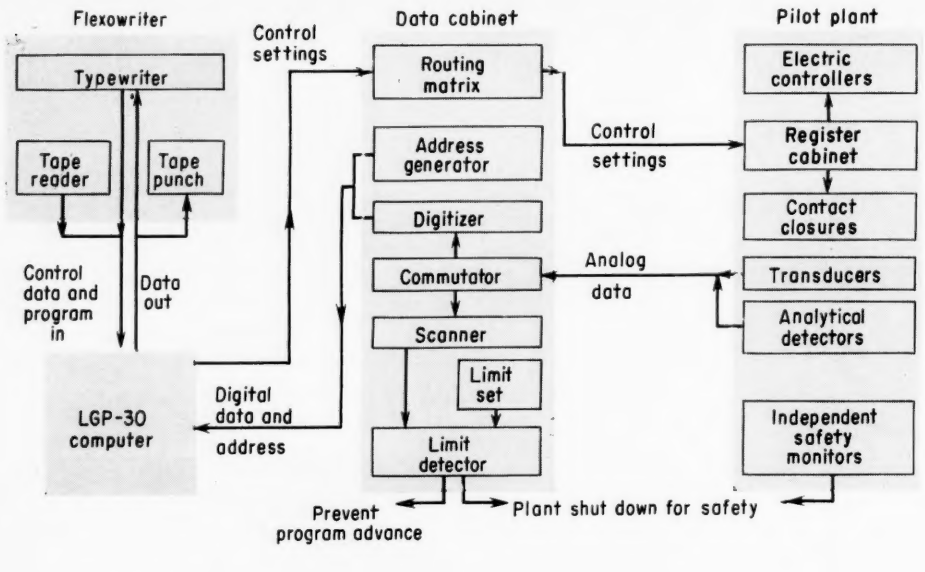
As the simplified flowsheet of the microplant shows, the process is conventional. Too, the unit is small; maximum liquid feed rate is less than a liter per hour.

Gas feed rate is controlled by an automatic valve. For catalyst regeneration, the desired oxygen-nitrogen mixture can be set by coiled capillary metering

How to justify computer-run unit—Table I

Item	Man-hr. Savings/ Year
Unattended operation	2,000
Results available immediately	1,000
Fewer runs due to greater accuracy	3,500
Analyses on-the-spot	2,000
More runs per year	3,500
	12,000

* Now with International Business Machines Corp.



A data cabinet links computer and the process —Fig. 1

tubes, bypassing the feed control valve. Regeneration gas composition is fixed by adjusting pressure regulators upstream from the capillaries. If preferred, air flow can be set by reactor temperature to control the feed mixture.

Gas and liquid feeds mix and then flow through a preheater into the first of several ⅜-in. I.D. reactor tubes in series. In the present reactor, which holds about 500 g. of solid catalyst and diluent, these tubes are inside a metal block cast around them (to maintain constant temperature).

Products from the reactor section are cooled, and liquid and gases separated at system pressure. Hydrogen is produced in hydroforming once the reaction starts, so some of it is recycled. Liquid level in the separator is maintained by a conventional electrical level control that operates a pneumatic needle valve. To take all C_4 and lighter hydrocarbons into the gas stream, the liquid product is distilled. A level controller discharges naphtha bottoms product into a slop tank or weight tank, as desired.

Controllers adjusting valves, heater current, pump stroke, etc., are in most cases conventional null-balance types. They match the desired control setting against the feedback measuring actual pump setting, or against transducer output itself.

Integrating Data and Process Systems

To control this process system—and also log and correct data, calculate and print out results, and select the test programs—a computer was needed. At the time the project was started, only two computers were available in the size and price required. Selling at less than $50,000, the Royal-McBee LGP-30 was selected.

Shown in the photograph on the previous page, the computer is in the foreground with its input-output typewriter and punched-tape reader. Behind it, the cabinet with the graphic panel contains electronic controllers, thermocouple converters, magnetic amplifiers, chromatographs and other control equipment. The pilot plant itself is located behind this central control cabinet.

At the right of the graphic panel is a smaller cabinet that contains oxygen, carbon dioxide and moisture analyzers. It has interlock equipment for safety shutdown. The cabinet at the left of the graphic panel contains digital setpoint registers, including a timer, and the electronic equipment associated with them.

At the far left of the picture is a "data cabinet." In it are hundreds of relays, diode matrix boards, etc., that make up such devices as analog/digital converters, off-limit detectors (and means for setting the limits), scanner, address generator and electronic "rings" for commutating 50 data points every 40 seconds. The intermediate data cabinet enables computer and pilot plant to converse despite a difference in language, translating between the binary digital signals of the computer and the analog signals of the pilot-plant control system.

Fig. 1 shows the role played by the data cabinet. Program, logic and control data are fed to the computer from either the keyboard or the punched-tape reader. The latter device can be the mechanical reader on the Flexowriter or a much faster photoelectric reader. Similarly, data and calculated results are printed or punched out on the Flexowriter.

Typical control-loop outputs are handled as shown in Fig. 2. At the left is a pneumatic output, at the right an electrical one. Both use conventional Swartwout controllers.

Adapting a Computer to Control

The LGP-30 general-purpose digital computer has a

rapidly revolving magnetic drum on which sixty-four 64-"word" tracks store a total of 4,096 data and program words. Each word contains 32 binary digits (bits), either 0 or 1, represented by the magnetic character of a particular small area on the drum. Though the computer normally operates by the binary system of arithmetic, the bits can be used in groups of four, operating with hexadecimal arithmetic ($2^4 = 16$). This simplifies computer programming since eight letters or numerals form a word, rather than 32. A "word" can be used for storing either an address and command, or an address and data.

To keep input operations to the computer as simple as possible, the digitizer in the data cabinet was designed to provide binary output. This permits direct input to the accumulator of the computer, four bits at a time, with no additional buffer storage required. In this way, time-consuming programmed conversion of decimal digits to binary form can be avoided. Synchronization of the data system and computer is extremely important, however, because data points are identified by the order of their serial introduction. Special circuits stop data to the computer if the two systems get out of synchronization. This helps to protect the stored program and assures proper assimilation of each piece of data before accepting the next.

Each data word has a 12-bit address portion for instruction, generated by a diode matrix, and a 12-bit data portion that is the digitized value of a d.c. analog signal. Every 800 milliseconds, the electronic commutator routes a new data point to the digitizer, where 12 mercury-wetted comparison relays successively feed a differential analyzer. Thus, the analog voltage is converted to a digital number between 0 and 4,096 in 200-400 ms. Not all data use the full 4,096 "counts," e.g., maximum weigh-tank reading of 1,500 g. is scaled to read exactly 3,000 counts—a precision of 0.5 g.

To feed control data in the opposite direction, i.e., from computer to plant, the stored binary or hexadecimal data must be converted to an analog voltage. This is done in 13 "digital set-point registers," which can be set by either manual buttons or the computer. In the second case, a relay switches output of the four computer thyratrons (normally operating typewriter keys) to relays in the digital set-point registers, so the latter can be set, four buttons at a time. Eight of the set-point registers permit control of up to eight operating variables with a precision of one part in 1,023 ($2^9 + 2^8 + \ldots + 2^0$).

Three other binary registers permit manual or programmed computer operation of up to 36 valves, pumps, switches, etc. Another register permits the computer program to establish the function of the computer in that operation—whether it is to take data and calculate it, or just scan the data, or print out oil cycle results or regeneration results, or take in control data from a paper tape, etc.

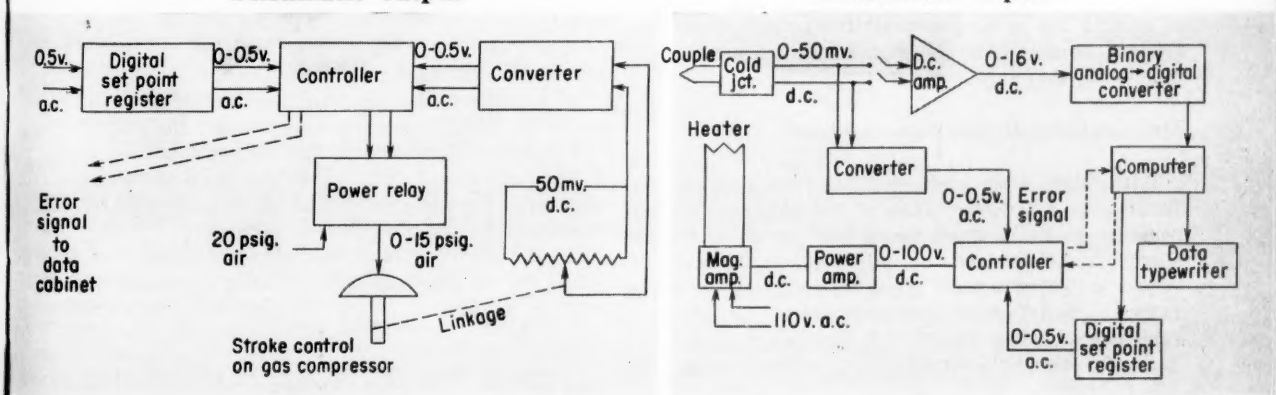
Still another such register sets the timer for the time in which the particular operation is to be completed. Each test run comprises about a dozen different operations that vary in time from 1 to 90 minutes. Automatic advance of the program after completing a given operation is controlled by this timer. When the selected time has expired, it transfers control back to the data cabinet. This generates an "advance program" address and initiates the next computer-controlled operation, provided all critical operating variables are within desired limits.

Computer Problems

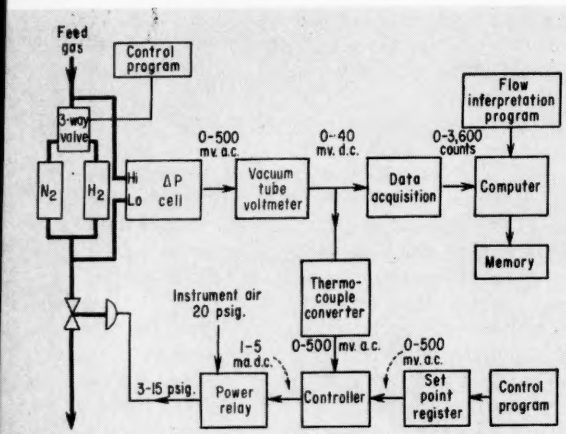
One problem that developed with computer control was a lack of sufficient memory capacity to store control data for more than about six test runs. The acceptance test program was of necessity wasteful of space since it was changed and patched repeatedly during the testing. A finished program would save up to 20 or 25% of the drum for control purposes. Even then, about one-third of the drum would be required for the three chromatograph programs.

The solution developed, however, gives the plant virtually unlimited storage capacity by providing

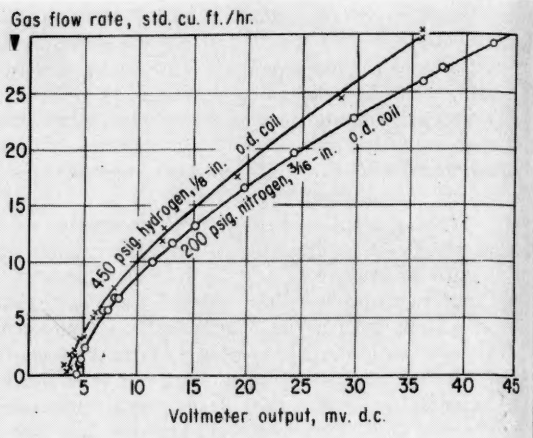
Typical control-loop outputs in computer-controlled system—Fig. 2



Block diagram of feed-gas flowmeter—Fig. 3



Feed-gas flow calibration curves—Fig. 4



equipment for automatic read-in of control data (or any other portions of the program desired) from a roll of punched tape. With this, the computer stores the control data for only one run at a time. After each run, it automatically starts the paper tape feed, reads off the conditions desired for the next run and then proceeds to carry it out.

Another problem occurred after the plant was moved to its rural New Jersey location. Brief (10-200 millisecond) power transients, normally unnoticed, disrupted computer operation. Those of over 5 ms. usually cause computer shutdown or upset the computer-plant synchronization, or shut down the plant under emergency procedures. One such shutdown during the final acceptance test was traced to switching operations in the utility company's substation several miles away. That firm's conventional damped meters showed only a 2-v. fluctuation.

Solution here is to supply computer and instrument power from a motor-generator set with a flywheel capable of maintaining sufficient frequency and voltage to coast over at least a 2-sec. power failure. Longer failures are so infrequent that the added cost of driving the motor-generator from continuously recharged storage batteries can hardly be justified in this program.

Measurement of Gas-Stream Flows

With H_2 or N_2 gas flows ranging from 3-30 std. cu. ft./hr. over a pressure range of 100-400 psig., it isn't practical to use a single-range instrument, providing a proportional electrical output, to obtain the required accuracy. After several types of electrical flowmeter proved unsatisfactory, measurement of ΔP across a capillary tube was adopted. A Swartwout transducer generates electrical signals from ΔP values of 0-20 in. of water.

By coiling the capillary tube,* the critical Reynolds number, corresponding to maximum velocity of laminar flow, can be increased from 2,100 to 15,000 or more. This correspondingly increases range up to sevenfold—pressure drop across the coiled capillary is a simple function of flow rate. Fig 3 shows a block diagram of the flowmeter. To measure the flow of hydrogen, a 0.055-in. I.D. coiled capillary is used; a 0.089-in. I.D. tube handles nitrogen. The computer-stored control program selects the proper coil

Fig. 4 shows typical flow calibration curves over a range of 3-30 std. cu. ft./hr. Actual pressure drop across the capillary is reproducible to at least 0.3% of full range. Over-all accuracy depends on sensitivity and stability of the transducer used. Since pressure and temperature are held constant for the feed gases, there is no need to compensate for them.

Measurement of product gas flows (1-35 std. cu. ft./hr.) poses a different problem because composition varies widely in reforming and regeneration cycles. Because the stream is vented after sampling, no flow control of the stream is necessary. Four modifications to a standard wet-test meter were made to meet system requirements:

1. A water saturator is used ahead of the meter to prevent loss of water.

2. A thermocouple measures gas temperature in the meter so that the computer can correct the volume.

3. Absolute pressure in the meter, measured with a ΔP transducer that compares ambient pressure against a trapped pressure of 15 psia., is also fed to the computer for correction of volume.

4. A continuous microtorque potentiometer on the shaft of the meter gives a periodic sawtooth output voltage to indicate, when interpreted by programmed

* Powell, H. H., and Browne, W. G., Use of Coiled Capillaries in a Convenient Laboratory Flowmeter, *Rev. Sci. Instruments*, 28, 138-141 (1957).

logic, the number of revolutions and precise position of the shaft.

Digitized values are as accurate as those read from the dial. At flow rates normally used, the wet-test meter itself had an accuracy of 0.25%.

Measurement of Liquid-Stream Flows

To approach the desired accuracy of 0.2 wt. %, precise metering of 125-1,000 cc./hr. of feed naphtha is necessary. Because no known flowmeters are sufficiently accurate, a Lapp Microflo pulsofeeder pump serves as flowmeter. Its stroke is positioned by a servo motor in the control system. A five-turn precision potentiometer on the stroke-control shaft feeds back actual shaft position to the controller.

Subjected to rigorous calibration checks, the liquid feed rate for a given digital set-point register setting consistently checked to better than one part in 700, provided that

- The head of liquid on the pump inlet was held constant.
- The back pressure on the pump was held constant by a simple gas-loaded regulator.
- The pump's check valves were in good condition and the feed well-filtered.

To assure material balances around 0.6% accuracy, measurement of liquid product to about 0.2% is necessary. A precision-bored stainless steel tube, 1.740 ± 0.001 in. I.D. and 64 in. high, holds liquid product during measurement. A Consolidated Electrodynamics Corp. precision pressure balance (an electromanometer) measures weight of the liquid with a precision approaching 0.1%. The only precaution needed was the use of sufficient small-bore tubing held precisely horizontal at the lower connection to absorb any movement of the liquid interface resulting from the slight bellows expansion in the instrument.

After the run is over, and upon command from the computer, a 12-step rotary distribution valve rotates one step, allowing liquid product to drain from the tank into one of six receivers.

Measurement of Product Composition

For accurate weight determination of product gas, a gas density measurement, using a Beckman Type 3A gas density meter, is made every 40 seconds. Density can also be a sensitive indicator of change of gas composition.

From hydrogen through C_5 hydrocarbons, a complete chromatographic analysis is made of a product gas sample taken at the start of each hourly run. To improve accuracy of the chromatograph, the sample is injected in a special way to broaden the methane and ethane peaks. The chromatograph electrical output is sampled every eight seconds, and the area under the "curve" is calculated in the computer. Hydrogen is not determined directly since it is used as the carrier gas. The chromatograph is calibrated to give the percentages of hydrocarbon components in the total stream directly, so hydrogen is obtained by difference from 100%. Chromatograph system, automatically programmed from the computer, has a built-in zero-adjustment circuit.

Two chromatographs analyze the liquid product, which consists of paraffinic and aromatic components. Hydrogen carrier gas sweeps the sample through both chromatograph columns. Though at first the two columns are series-connected, at a selected time after sampling they are switched to operate in parallel. Aromatics are held back, then resolved in the first column; lighter paraffins are trapped and resolved in the second. To shorten analysis, hydrogen flow through the first column is tripled after the benzene peak has gone through. A complete analysis of C_4-C_8 paraffin and C_6-C_9 aromatics can easily be made in the 57 minutes available, but considerable effort was required to obtain proper sample timing and stable, trouble-free operation.

Monitoring for Safety

During the on-condition period of reforming operations, it is desirable to have a record of process variables that were outside certain prescribed limits. These variables include reactor pressure, reactor temperature, feed-gas flow rate, etc. Variables are checked and recorded when outside the prescribed range, and the computer stores, and prints out at the end of the run, error magnitude and direction, point identification, and time of occurrence. In this way, all pertinent operating information is logged for a given run, and necessary corrections to the data can be made.

With an unattended plant handling highly combustible components, such as hydrogen and hydrocarbons, it is essential that the plant automatically monitor itself and shut down when unsafe conditions develop. To permit containment of any leakage, the process proper is totally enclosed and separated from control and data-acquisition and processing equipment. A combustible analyzer samples the atmosphere at several points in the process cabinet. It automatically shuts down the plant and turns on an exhaust fan before a hazardous level is reached. Opening a door in the plant enclosure can, if desired, automatically shut down the plant.

Other major safety steps that include shutdown are:

- Fire detectors automatically flood the plant with CO_2.
- Primary and secondary safety devices monitor for excessive reactor temperature.
- A primary pressure-limit switch monitors for excessive pressure.

Less critical alarms simply prevent the operating program from advancing to the next step.

To insure that the plant is tight enough to obtain a satisfactory material balance, a leak test is automatically programmed before each new process run. This operation isolates the plant while it is pressur-

ized to 400 psig. with hydrogen, and tests any pressure loss against an equal 400-psig. pressure temporarily trapped on the other side of a differential-pressure transducer. If pressure loss exceeds 1 psi. (measured as 134 counts on the digitizer) over a period of 10 minutes, further operation of the plant is prevented and an alarm given.

Test Results Are Promising

Mechanical tightness during the acceptance tests was gratifying. By use of a helium leak-detector, leakage had been brought down to about 10% of the tolerance before the acceptance test. After about a week of operation, leakage had increased to only 50% of the tolerance. No servicing, such as tightening of valve packings, was performed.

Other than the acceptance tests, no operations have yet been conducted, so no extended experience for reliability is available. During the week of continuous running for the acceptance test, only two minor breakdowns occurred. One was a burned-out computer circuit tube. An engineer found and replaced the tube in about a half-hour.

In preliminary acceptance tests, a series of runs were made at 800 F., at which no reaction occurs. To test analytical and other equipment, and establish accuracy and material balance, synthetic gas and liquid products were fed through the plant. Following this no-reaction test, two series of runs were made with reaction occurring, just as the unit normally would be used. Results are shown in the table below.

The somewhat higher deviation in the last five runs is believed due to a partially plugged filter (since eliminated) in the product drain line from the stabilizer which backed liquid up into the enlarged section of the still-pot, thereby varying holdup. Material balances with a 2σ certainty of less than 1% seem feasible. This is only half as much deviation as our conventional pilot units show.

Shown in the table at the right below are the desired accuracy and that realized in the initial acceptance tests. Considering the small flow rates (150-925 cc./hr. liquid feed), the plant came remarkably close to meeting goals. It represents a great improvement over our existing units of this size, which exhibit material balances of 1.5-2% (1σ limits) even after months of attention.

To establish the unit's ability to make accurate carbon balances when burning carbon off catalyst pills, regeneration tests were made. For each test, a freshly weighed batch of carbonized catalyst was placed in the reactor. Fig. 5 shows a typical plot of CO_2 in the exit gas. Note that there is no sharp drop in the CO_2. This shows that there was no sharp "flame front," probably because of high velocity and the isothermal character of the reactor. Burning took place in several tubes at once. Thermocouple readings also showed no flame front traveling through the reactor.

As a check on digitizer and computer calculation accuracy, amount of carbon in the outlet gas was obtained in two ways. One was to read the value of CO_2 periodically from the panel meter, plot it, and integrate the curve by hand. The other way was computer printout of calculations from CO_2 values digitized every 40 seconds. Data in the table with Fig. 5 show that computer values agreed well with those calculated by hand, and were certainly more consistent.

Catalysts used in the last five tests showed a higher carbon content in the microplant than in the laboratory analyses. A sample returned to the lab for reinspection showed the laboratory analysis to be in error. Plant material balances showed excellent reproducibility; carbon balances accurate to 1% should be feasible.

Several Lessons for the Future

Some lessons are already evident from this venture.

Workers of many different talents are required, and their efforts must be coordinated toward the common end. Chemical engineers with process experience, engineers with instrument experience, electronic design engineers, electrical technicians, and a computer programmer with engineering or process background, are all essential for efficient progress.

Results of initial acceptance tests—Table II

Material balance

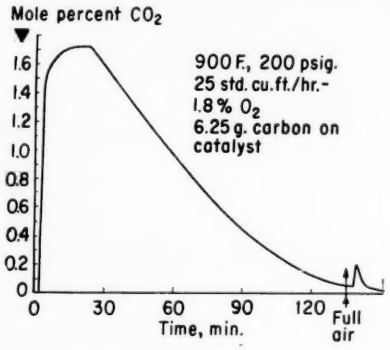
	A	C-I	C-II
Reaction	No	Yes	Yes
Number of runs	15	6	5
Material balance			
Range, %	98.7–101.6	98.4–101.2	97.6–101.4
Average, %	100.17	100.13	99.9
Average deviation, %	±0.80	±0.89	±1.3
% standard deviation	0.93	0.92	1.6

Accuracy

	Desired	Realized
Pressure	±5 psig.	±3 psig.
Temperature	±1 deg. F	±1.5 deg. F
Liquid feed rate	0.1%	0.15%
Gas feed rate	0.5%	0.5–2.0% *
Recycle gas rate	5.0%	3%
Liquid product	0.2%	0.2%
Gas yield	0.5%	0.3–1.0% *
Material balance	0.6%	0.9%

* Varies with rate and range used.

Regeneration tests show accuracy of carbon balance—Fig. 5



Carbon found in outlet gas

Carbon charged, grams	Carbon found: Hand calc., grams	Carbon found: Computer calc., grams	Carbon balance: Hand calc., %	Carbon balance: Computer calc., %
10.3	10.16	.....	99	.....
10.3	10.68	(10.42)	103.5	(101.1)
5.68	5.84	6.19	103	109
5.68	6.12	.....	108	.....
5.68	6.10	6.17	107.4	108.8
5.68	6.26	6.26	110.3	110.3
5.68	6.13	6.16	108.0	108.4

Conversion of proprietary instruments and control equipment to meet accuracy specifications of automated research equipment may be a problem, particularly if flexibility and reliability must remain high. The small quantities of material processed present special problems, such as the necessity of design that minimizes holdup and leakage.

There is a tendency, in building an automated pilot plant, to omit visual indicators such as pressure gages, bubblers and temperature recorders, but this is a mistake. Without such helps, proper plant startup, daily servicing and periodic checking become difficult. Similarly, since accuracy is so important, provision for quick calibration checks is desirable.

Besides visual indicators, alarms have been added to the computer-controlled microplant to call nearby personnel when serious malfunctions develop. Such hazards include failure of a level control, allowing liquid in a gas line; a chromatograph peak off-scale because of insufficient attenuation; pressure-drop buildup in the reactor, or the filter following it; no advance of the program after a reasonable time interval.

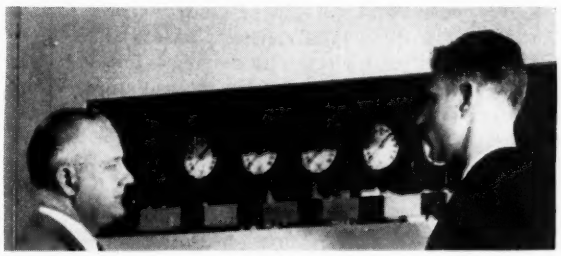
The ease with which the computer program can be wrecked—not only by power-line transients, but by operating errors, false data, excessive electrical "noise," etc.—suggests using a protected program. Such protection involves shutting off most memory "writing" circuits after the final program is on the storage drum and debugged. It means extra programming effort, but it may be worth it to improve the service factor.

We hope to incorporate this latter feature when we rewrite the computer program to save some memory for more advanced "thinking" by the computer. An example of such thinking is searching for optimum process conditions or economics. Another is for the computer to govern its own operating program, e.g., calculating product octane number from analyses, and adjusting operating temperature to compensate for loss in catalyst activity, so that product quality is held constant and catalyst deactivation rate automatically established.

All of these areas of research and development take time and special effort. This must be recognized by both vendor and customer, to reach a reasonable pricing of the ultimate system. Future standardization of equipment used in the construction of such a unit, however, will extend the applications by reducing overall system development time.

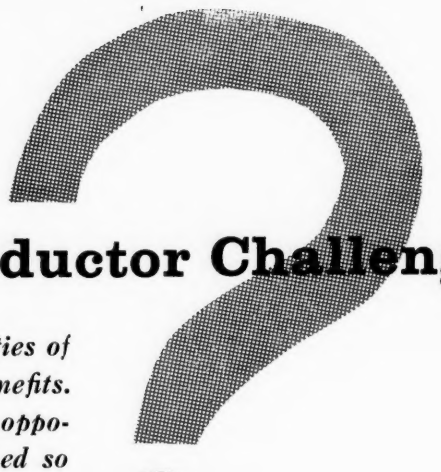
We believe that automation of pilot plants is feasible, but it requires solution of new (and sometimes unexpected) problems. It can, however, pay off by reducing manpower and time in the pilot program, and—more important—providing more-accurate pilot results.

Meet the Authors



F. R. RUSSELL *(left) has been with Esso Research and Engineering since taking his Ph.D. in chemical engineering at M.I.T. in 1936. Now at the Florham Park, N. J., facility of the firm, Russell has tackled all of the major processes of an oil refinery during his career. During World War II, he worked on incendiary-bomb development and the Manhattan Project's centrifugal gas separation work. He is a member of the American Institute of Chemical Engineers.*

C. W. DOWDING *(right) is now a data processing systems engineer with International Business Machines Corp. in Los Angeles, but at the time this article was prepared he was associated with the work at Consolidated Systems Corp., Pasadena, on the computer-controlled pilot plant. He is a graduate of University of British Columbia (B.S.Ch.E.); his previous work was with Shell Oil and C. F. Braun.*



The Organic Semiconductor Challenge

Research into the enhanced electronic properties of organic compounds may yield tremendous benefits. Some of these are indicated in the table on the opposite page. Here is what has been accomplished so far, the current trends and future potentialities.

HERBERT A. POHL, *Princeton University*

Those who venture into the study of organic semiconductors soon find that they have landed, spread-eagled, in an interdisciplinary field of research that embraces parts of organic, polymer and physical chemistry, as well as physics and biology. The field is enormously exciting but untamed. It is full of pitfalls for the unwary and for those whose knowledge of other fields leads them to regard this one overconfidently.

The phenomenon of semiconduction was recognized over 120 years ago by Michael Faraday when he noted that, under a given electric field, silver sulfide does not conduct as much electricity as metals but definitely more than other materials known as insulators. While the subject then lay dormant for more than a century, the great reawakening of interest in it during the last two decades has brought inorganic semiconducting devices such as transistors into commercial as well as scientific prominence.

As for organic semiconductors, while their commercial use for transistor material is not around the corner, their potential is exciting indeed. Not only can they help us to understand and perhaps duplicate biological reactions such as photosynthesis and direct energy conversion, but they may find significant applications in catalysis, sea-water conversion, electron-exchange resins, thermoelectric power, solid-state batteries, solid-state electrolytes, and information storage components, to name just a few. The field offers fertile ground to the molecular engineers—those who wish eventually to be able to produce materials of any preconceived characteristics.

There is certainly much to explore. For example, the "inventor's table" on the next page shows the voids in our present technology that could be filled by devices that utilize enhanced electronic properties of organic materials. Furthermore, such problems as the breakdown of organic insulators to form conducting paths (largely of pyro-polymer) needs serious and organized study.

The Organic Storehouse

The many laboratories in this country and Europe that are working on some phase of organic semiconduction can draw from a tremendously large and varied storehouse. Organic substances range from being the best of insulators, with resistivities as high as 10^{22} ohm-cm., to being conductors as good as some metals (10^{-4} ohm-cm.). This range of 10^{26} can be covered by material containing only carbon, hydrogen and oxygen. In addition, one can already choose from organic semiconductors with temperature coefficients of conduction that are positive, zero or negative; from *n*-type or *p*-type semiconductors; from those with high or low, positive, zero or negative thermoelectric power (Seebeck coefficient); and from those that are dia-magnetic, nil-magnetic or para-magnetic. Some organic materials can be formed into electrets, the electrical analogue of magnets. The range of available dielectric constants is enormous—from less than 2 to over 4,000, the latter materials being ferro-electrics.

Organic materials with enhanced electronic properties range in form from semiliquid to solid, from noncrystalline to single crystal, from very soft to very hard (diamond). This is but a partial listing of the range of attributes of organic semiconductors. The storehouse from which the molecular engineer may draw, and upon which he may skillfully redesign on nature, is getting larger and shows sign of becoming enormous.

Conductivity Factors

Enhanced electronic properties are generally observed only in organic compounds that contain highly

conjugated bonding, such as aromatic compounds with numerous condensed rings. An extreme form of this, eka-conjugation, appears to be involved in the highly conducting polymers. In eka-conjugation, the degree of conjugated bonding is high enough to permit appreciable fractions of the material to exist in excited electronic states while at equilibrium at room temperature. The study of the new and unusual properties of eka-conjugated organic compounds is in itself an exciting new field of organic chemistry.

For the purposes of this discussion, we shall define as a semiconductor any material having a specific conductivity, σ, lying between 10^{+4} and 10^{-12} mho/cm, and usually having: a conductivity that increases as the temperature rises, a large thermoelectric power, rectification properties at the junction boundaries with other conductors—and often exhibiting photovoltage or photoconduction of marked degree.

The conductivity of a material is, of course, proportional to the number of free charge carriers, to the size of charge each carries, and to the ease with which the carriers move. This basic relationship is expressed in the fundamental equation for conduction:

$$\sigma = |e| \cdot n \cdot u$$

where σ is the specific conductivity, usually expressed in mho/cm., (representing the current in amperes across a unit cube one centimeter on a side, when unit field is applied); $|e|$ is the charge on the electron (1.602×10^{-19} coulombs); n is the number of charge carriers (electrons in this case); and u is the mobility, in cm.^{2}/volt-sec., (i.e., the average velocity of the charge carriers in unit field strength).

As the size of each charge is constant, conductivity depends on two main factors in a given material—the number of available charge carriers, and their mobility. The following table may serve as a rough guide as to orders of magnitude for these two characteristics:

Substance	Carrier Concentration, No./Cu. Cm.	Mobility, Cm.^{2}/Volt-Sec.
Metals	10^{21}–10^{22}	10 –10^6
Inorganic semiconductors	10^{11}–10^{20}	10^{-4}–10^5
Organic semiconductors	10^9 –10^{21}	10^{-6}–10^2
Organic insulators	Less than 10^9	10^{-7}–10

The challenge to inventors and trail blazers

Devices that use organic material with enhanced electronic properties could eventually replace the question marks. This would enable the types of energy shown along the top of the chart to elicit any of the responses shown along the side.

	Initialing Energy						
Response	**Electro-**	**Magneto-**	**Actino-**	**Phono-**	**Piezo-**	**Chemi-**	**Thermo-**
Conduction (motion of electrical charge)	Transistor Electret*	Hall-effect switch	Counters Photoconduction	?	Piezo-electric crystals	?	Thermistor Thermocouple Superconductors
Magnetization	—	Memory devices Magnet	?	?	?	?	Memory devices Supermagnets*
Light emission or sorption	Electro-luminescent panels Light amplifier	?	Maser Laser Electronic shutters*	?	Tribo-electricity	Bio-luminescence Luminol*	Temperature-indicating dyes
Mechanical response	Electrostriction Ultrasonic generator	Ultrasonics Magnetostriction	?	?	?	Muscle	Bimetallic elements Biplastic elements*
Chemical action	H_2O desalting* Catalysis Electrolysis	?	Photosynthesis	Cavitation degradation*	Rupture of macromolecules Fiber fatigue	—	—
Thermal response	Resistors Heated wind shields*	Debye's magnetic cooling	—	?	Gunpowder Explosives	?	Thermal trigger for spontaneous reactions
Surface effects	Free radical capture*	?	Catalysis	?	Catalysts Enzymes	—	—

*Yet to become practical

In inorganic semiconductors, it is not difficult to attain high carrier concentrations, especially by the use of dopants, or impurities; in fact, purity is judged by the lowness of carrier concentration attained. The major problem is one of getting high mobilities. Broadly speaking, this also applies to work on organic semiconductors, so that mobility may be one way of classifying semiconductors, as is shown by:

Mobility Quality	Mobility, $Cm.^2/Volt\text{-}Sec.$	Examples
High.....	1,000–100,000+	Ge, Bi_2Te_3, Si
Intermediate..	1–1,000	Pyro-polymers, diamond, graphite, anthracene, ZnO, Se, Cu_2O
Low.....	Less than 1.0	PAQR* polymers, organic complexes, many inorganic ionic semiconductors

* Polyacene quinone radical

The above table seems to contain an apparent anomaly. Anthracene, which we shall see is a good insulator, has perhaps a surprisingly high mobility. The conductivity is very low because the number of free carriers is very low (about 1,000/cu.cm.). On the other hand, some rather highly conductive organic semiconductors—the PAQR polymers—have very high carrier densities (about 10^{19}/cu.cm.) but low mobilities (about 10^{-2}). This bears out that it is not just the number of carriers available, nor merely their mobilities, but the combination of the two factors that determines the degree to which a material will show enhanced semiconduction.

Keeping these factors in mind, let us now pass on to a consideration of the various organic semiconductors.

Unfortunately, we must face the possibility that the experimental value obtained for the conductivity contains some associated errors. These errors may be large. Perhaps the greatest source of error, one that makes the conductivity appear too high, is the presence of moisture or other conducting ionic impurity in the sample.

Apart from this, however, the effect of impurities upon the conductivity of organic compounds does not seem to be very great. This is in rather striking contrast to the generally very great effect of impurities on the high-mobility inorganic semiconductors.

Also affecting conductivity is the orientation of the material and the anisotropy of conduction (variation of conduction depending on direction in which it is measured). There are still other factors, such as morphology (e.g., single-crystal vs. powder, or vs. amorphous solid), but so far not too much is known about their specific effects except to note that while they are measurable they are often not large.

It is convenient to subdivide the discussion of the various organic materials by considering first the small monomeric molecules, then the complexes, then the polymers, then the superpolymers. Conductivity generally increases in this order, although there are many exceptions; and it obeys an exponential law as regards temperature variation. Plots of the log of the conductivity vs. the reciprocal temperature are straight lines, except for short regions where there is a change in the dominant mode of conduction.

Electronic Properties of Monomers

The simpler organic molecules have been studied rather extensively. In particular, napthalene and anthracene have served as model compounds for thoroughgoing investigations. Because these materials have such low conductivities, (about 10^{-16} and 10^{-18} mho/cm., respectively) the experimental difficulties are severe and are often reflected in poor agreement between researchers. On considering the experimental results obtained with these and other simple organic molecules, one can draw up a number of rules, as shown on the opposite page.

The organic semiconductors, just like the inorganic ones, can be characterized by the type of carrier that appears to be dominant in the portage of current. A semiconductor may be either *n*-type or *p*-type, for example. In the former, the electrons appear to carry more of the current. In the latter, electronic vacancies, or "holes," carry most of the current. The work of Nelson[3] indicates that the cationic dyes are *n*-type semiconductors, while the anionic dyes are *p*-type, for example.

After long controversy over the nature of semiconduction in the simpler monomeric organic molecules, there is growing agreement that for the most part it is only the mobility and not the carrier concentration that is moderately high in these materials. The carriers must be injected or supplied by other means, such as special electrodes or light impingement. Extensive studies on the aromatic hydrocarbons bear this out, showing that the pure materials are relatively poor semiconductors.

The conductivity generally increases as the size of the fused aromatic nuclei portion increases (see Rule 1). Whether or not the molecule is a stable free radical does not seem to increase the conductivity very much beyond what one might expect from the already large size of the organic free radical. If molecular interbonding is such as to permit electronic interchange (as in complexes or salts), then the free radical nature becomes important for conduction, as indicated under Rule 3.

The phthalocyanine molecule, which is analogous to the central structure of a number of biologically important compounds such as heme or chlorophyll, can sequester a metal atom in its center. The various pythalocyanines, with or without metal atoms, are quite heat-stable and exhibit conductivities of about 10^{-11} to 10^{-10} mho/cm.

Several experimental devices have been made using compressed pellets of phthalocyanine. Haack and Rust[4] found that a light doping with traces of inorganic acid permitted the materials to exhibit rectification when located between differing metal electrodes. Calvin[5, 6] et al., observed that coating a pellet face with air-oxidized amine yielded a structure capable of generating photovoltage when illuminated. Similar be-

havior was observed with structures formed from coronene and chloranil. Such experiments are most interesting because they may shed much light upon processes of biological interest, such as photosynthesis and cancer initiation.

Coordination Polymers and Molecular Complexes

Let us now consider molecules in which greater intermolecular orbital interactions are induced by the use of bonding.

Aside from van der Waals' type of bonding between molecules, such as in the compounds already considered, there is covalency, coordinate valency, and ionic valency. The study of electron donor-acceptor complexes of organic compounds has shown that it is possible to create considerable interlocking of molecular orbitals and greatly enhance the electronic properties of the components. Various aromatic hydrocarbons such as pyrene, perylene or violanthrene, if complexed with I_2, for example, will conduct better by a factor of 10^6 or more than either of the single components. Akamatsu[7] et al., prepared violanthrene-I_2 complexes with specific conductivities of up to 0.02 mho/cm., while I_2 and violanthrene have individual conductivities of less than 2×10^{-10} mho/cm.

The number of complex pairs studied is already large. It includes hydrocarbon-alkali metal;[8] hydrocarbon-halogen and diamine-quinone complexes. Eley and co-workers[9] in England, and Labes, Sehr and Bose[10] in this country, have been particularly active in this field. Most of the complexes studied so far have been rather unstable. The conductivities range from 10^{-1} to 10^{-12} mho/cm. The properties of a typical polymeric complex made with *p*-phenylene diamine and chloranil in the form of a compressed briquette of microcrystals run as follows:[10, 1]

Specific conductivity	$\sigma = 10^{-8}$ mho/cm., at room temp.
Activation energy of conduction	$E_a = 0.57$ eV
Thermoelectric power (Seebeck coefficient)	$Q = 1.1 \times 10^{-3}$ v./°C
Thermal conductivity	$K = 2.0 \times 10^{-3}$ w./cm.°C
"Figure of merit," $Z = Q^2 \sigma / K$	$Z = 10^{-11}$
Mobility—u_e for electrons,	$u_e = 2.0$ cm.²/volt-sec.
u_h for holes	$u_h = 7.0$ cm.²/volt-sec.
Carrier concentration (intrinsic model) ($c = 0.282 = u_e/u_h$)	$n_i = 7 \times 10^9$/cu. cm.

Polymers as Semiconductors

Let us turn to compounds consisting of molecular segments joined not by coordinated valances, but by covalency, or by ionic valences. We shall discuss the directly synthesized polymers that show semiconduction, and touch briefly on the natural polymers, the proteins.

In the past, synthetic polymers were thought of primarily as a source of insulators. It has been thoroughly demonstrated recently, however, that polymers may have enhanced electronic properties. Over 100 such polymers have been synthesized at the Princeton University Plastics Laboratory. A large number were of the polyacene quinone radical (PAQR) type.[1] They were synthesized by condensation reactions from various aromatic hydrocarbons or their derivatives, using various aromatic acid anhydrides. The conductivities ranged from 10^{-2} to 10^{-10} mho/cm., and materials of both *n*-type and *p*-type were prepared. The Seebeck coefficients ranged from -20 to $+1{,}100$ microvolts/°K. The activation energies of conduction, as calculated from the relation $\sigma = \sigma_o \exp. (-E_a/kT)$; ranged from 0.13 to 0.9 *eV*.

As would be expected, these semiconductors could be made to exhibit photoconduction, and to produce photovoltage when properly coupled with other electrode materials.

The PAQR polymers evidently contain high concentrations of electron "spins" or unpaired electrons. This can be most conveniently attributed to the existence of stable free radicals, probably bi-radicals, as eka-conjugation is present in appreciable amount. The conductivity can then be attributed to the conversion of a portion of the eka-conjugated molecules to the ionic species that serve as carriers.

A proportion between the spin concentration and carrier concentration is observed when we proceed

The electronic behavior of simple organic molecules seems to follow these rules:

1. Molecular structures that permit a maximum of electron orbital interlap between neighboring molecules favor high mobility, high carrier concentration and high conductivity. Ion-radical salts are an example of such structures. There is some evidence that hydrogen bonding accentuates electronic conduction.
2. Conductivity is accentuated in those molecular structures that bring about a lowering of the excitation energy required to produce excited singlet or triplet electronic states.
3. Increase of size of the contiguous region of conjugation enhances conduction.
4. The presence of two or more single bonds in series between the more conjugated or aromatic portions of a molecule drastically reduces the conductivity. Compounds with such structures are generally insulators, with conductivities less than 10^{-12} mho/cm.
5. The inclusion of atoms other than C, H, or O often appears to enhance the conductivity.
6. In the same organic compound, the liquid state is more conductive than the crystalline solid state.
7. Electronic conductivity is high only in very dark or black compounds.

Pyrolysis can produce wide range of electronic properties

Property	Range Obtainable
Type of semiconductor	*n*-type (electron donor) or *p*-type (electron acceptor)
Hall coefficient (inversely proportional to the carrier concentration)	−0.05 to +0.5 cu. cm./coulomb
Electron-spin density	Up to 10^{20}/cu. cm.
Seebeck coefficient	−10 to +100 microvolts/°K.
Temperature-resistance coefficient*	−0.005 to zero, to +0.1eV
Magnetic susceptibility	Diamagnetic to paramagnetic

*As expressed by E_g, the energy gap in the equation for degenerate semiconductors

through a homologous series of polymers. The population of spins may run up to 10^{21}/cu. cm., that of the carriers up to a small fraction of that.

Polymers of related structure have been studied in Australia.[11] However, after it was reported that Weiss had successfully synthesized a polymer with a conductivity of about 1 mho/cm., a "eucalyptus curtain of secrecy" has been placed about the work in that group.

Also, related to the PAQR polymers are the polydiketones, recently synthesized at the Princeton Plastics Laboratory. Their electrical properties are similar to those of the PAQR polymers.

Among the other polymers studied here at Princeton are polyphenyl,[12] aromatic thioethers, aniline blacks, various ferrocene-containing polymers, quinazonium polymers, and substituted polyacenes.

Polyphenyl, which is a linear chain of aromatic rings, exhibited conductivity of about 10^{-10} mho/cm.; polytetrachlorophenyl thioether samples ranged widely in conductivity, from 1 mho/cm. to 10^{-7}, depending upon the method of synthesis. The low conductivity sample exhibited rectification if placed between dissimilar metal electrodes. Aniline blacks so far prepared showed only low conductivity, 10^{-10} mho/cm., approximately.

Ferrocene[1] is a sandwich-type compound, with an iron atom bound between two hydrocarbon layers. Chemically, it resembles the smaller aromatic hydrocarbons in many ways. It is basically an insulator, and if this molecular group is attached to a vinyl group and the latter is polymerized, the result is, like its analogue polystyrene, an insulator (Rule 2).

If the ferrocene group is linked in a polymer by the π-electron-rich keto group, limited semiconduction takes place, ranging from 10^{-9} to 10^{-11} mho/cm.[1, 2] Linking the ferrocene groups with benzal groups yields polymers with conductivities of about 10^{-8} mho/cm.

Quinazonium polymers, prepared from quinones and isocyanates, have conductivities generally less than 10^{-11} mho/cm. The reddish black polyacenes obtained from sodium-potassium alloy treatment of tetrabromobenzene were of low conductivity, less than 10^{-10} mho/cm.

Japanese workers produced a conductive material by heating aromatic hydrocarbons with sulfur. Conductivities of about 10^{-4} were observed. Copper phthalocyanine polymers with extensive cross-linking were found to be quite conductive (10^{-4}, 10^{-8} mho/cm.).[14, 15] The increase of conduction upon polymerization of the phthalocyanine molecule (which in the monomeric form has a conductivity of 10^{-10} to 10^{-11} mho/cm.) is a good example of the efficacy of bonding to increase electronic conductivity (Rule 3).

Polyvinylidene chloride, which is ordinarily a good insulator, can be made into a poor semiconductor, having conductivity of 10^{-13} mho/cm., by the action of chemical agents that extract HCl.[16]

As for natural polymers, observations show that proteins in the dry state conduct only very slightly,[9] and they may be good insulators, as in the case of albumin (10^{-21} mho/cm.). If wet, it appears that they do conduct, but by electrolytic rather than electronic means, and about as well as water.[17] Hydrogen-ion transport is thought to be taking place in this instance.

Organic Superpolymers

Let us now consider those materials that have the molecular groupings linked in three dimensions by strong bonds, and that have very long range order or dimension, such as diamond, graphite, or organic salt crystals.

Although most organic salts examined do not possess high conductivity, there is an outstanding exception in the recently discovered salts of the free-radical type.[18] With organic free-radicals such as diphenylpicrylhydrazyl and the like, the conductivities range from 10^{-8} to 10^{-15} mho/cm. This does not represent a great departure from compounds of similar but nonradical aromaticity and dimension. However, in the case of those free-radical salts that have particularly favorable structures for electronic orbital interactions between molecules, such as the organic free-radical salts of tetracyanoquinodimethane (TCNQ), the conductivity can be rather high. The quinolinium salt of TCNQ, for example, is a degenerate semiconductor

with a conductivity of 100 mho/cm. Such radical salt crystals show a particularly large anisotropy of conduction.

The heating of organic compounds to extreme temperatures yields several classes of highly conductive solids. Those obtained at temperatures up to about 1,200 C. still contain appreciable proportions of elements other than carbon, and are referred to as pyropolymers.[19] Substances obtained by pyrolysis at still higher temperatures are essentially pure carbon. Typical products of this second group are the polymer carbons, the pyrolytic graphites,[20] graphite and, at combined high pressure and temperature, diamond.

The polymer carbons exhibit high electronic conductivity, ranging from 1 to 10^3 mho/cm. Recent highly interesting samples of density 1.5 to 1.8, obtained by F. C. Cowlard at Plessey, Ltd., in England, are nonporous and show promise as inert containers for various semiconductor compound preparations.

The pyrolytic graphites,[20] obtained by pyrolysis from the vapor, form in layers that exhibit marked anisotropy of both heat and electrical conduction. Materials have been obtained where conduction differs by a factor of thousands, depending upon the direction. Conduction along the nets of the graphitic structure is highest; perpendicular to the planes of the nets, it is lowest.

The pyro-polymers have been the subject of much study.[21, 22, 23] They can be prepared by the pyrolysis of most organic compounds in an inert atmosphere. A critical variable is the maximum temperature T_h to which the pyrolysis is carrier. Metallic or nonmetallic doping can also be performed. This technique can produce a wide variety of materials with electronic properties that differ in the extreme, as shown in the table on p. 108. If the materials are kept in an inert atmosphere, they are generally property-stable to within several hundred degrees of T_h.

The pyro-polymers are made up of highly condensed aromatic structures, and X rays indicate that these are arranged in small stacks of sheetlike nets. The order of packing of the stacks is jumbled. A large fraction of the carbon atoms lies at a stack boundary.

The pyro-polymers form a good example of eka-conjugation carried to a high degree, and they can thus help the organic chemist in the development of other eka-conjugated structures. The future should bring some exciting developments in this field.

This concludes our survey of the properties of existing organic semiconductors. Let us now consider the practical uses to which they can be put.

What Does Tomorrow Have in Store?

Where can organic semiconductors fit in man's world? What can study of them contribute? It is the writer's feeling that if 100 years from now someone were to review all contributions to human progress that had resulted from the study of organic semiconductors, he might well pick out the contribution to our knowledge of biological processes as being the one of greatest significance. However, he undoubtedly would find it difficult to ignore the physical uses developed for organic semiconductors during those years.

We already strongly suspect that organic semiconductors play a role in such life processes as vision, photosynthesis, in the actinic activation of cancer, and in energy transfer. And that's only a beginning.

The areas in which study of organic semiconductors can affect physical sciences and engineering are many. What we see now in the growing number of solid-state devices is only a sample of what is to come.

Let us refer again to the table on p. 105. Across the top is listed the type of energy that we may choose to activate our given material. The types of response that could be elicited are shown along the side. This is really an inventor's table, and you are the inventor. It remains for you to fill in the spaces with examples of the devices that will do the various jobs possible. As you see, some of the spaces are already filled in by a name or by an existing device. Some of the devices listed are new (e.g., the transistor) and some are old (e.g., explosives). Many blocks need filling—these will need new inventions, and many of these inventions will make use of the enhanced electronic properties of many organic compounds. Some clues as to how this can be accomplished already exist. The challenge is large and the result appears rewarding.

Perhaps the subject of future uses deserves to be put still another way. Consider first the chemical applications. Sea water could conceivably be desalted by using a semiconductive ion-exchange-type sorbant. Ions that are sorbed on it from the water could be removed later, and the sorbant regenerated either continuously, or batch-wise by electrolysis. Such a resin would need a high exchange capacity, chemical stability, and a conductivity at least comparable with that of the sea water.

In an analogous manner, one can conceive of semiconductive electron-exchange resins for the processing and purification of chemical liquors. These redox resins would oxidize or reduce the substrate passing through at selected potentials; they would operate reversibly, and would add only a minimum of extraneous materials.

Concepts indigenous to the semiconductor field have already contributed to a significant advance in the art of catalysis. Recent studies on catalysis by carbons indicate that further advances will be large and rapidly forthcoming. Interfacial catalysis may receive a boost from the "enzyme sandwich" technique, whereby such structures as layers of prosthetic groups, semiconducting material and energetic material can produce desired stereospecific chemical transformations at low temperatures.

Another application for organic semiconductors involves chemi-luminescence—the production of cold light—and this may work out to be economically justifiable for limited purposes.

The possibility of inert, high-temperature stable electrodes fashioned from certain polymer carbons has

already been demonstrated on a laboratory scale.

There are a number of uses for organic semiconductors for which there are natural models. The process of vision, for example, appears to involve organic semiconduction in the discrimination "circuit."

Muscle presents a model for direct conversion of chemical energy to mechanical work, and some success has been had by researchers in imitating muscle action in vitro. A step beyond this is the development of the catalytic system for supplying energy via processes presumed to involve organic semiconductors at the molecular level.

Photosynthesis stands as a challenge. If man could develop his own photosynthesizers, he presumably could see the day when selected sheets of them would lie in the sun, absorbing CO_2 and H_2O, and dripping carbohydrates or similar compounds. Different syntheses in various chemical atmospheres would produce other desired products.

Let's turn from the chemical to the electrophysical applications of organic semiconductors. In space, defense, electronics, or industrial technology, the following uses come to mind: thermoelectric power, phosphor modifiers, solid-state batteries, solid-state electrolytes, and components for ferro-electric, energy storage or memory devices.

Organic semiconductors may assist in forming cold cathode or cold anode components, or in electronic copying of printed or photographic material. In compounds such as the sydnones, one already has an example of an "electronic optical shutter," for these materials have the property of becoming opaque to a wide region of the optical spectrum, upon being irradiated by ultraviolet. Further work on this principle should prove rewarding.

Besides using organic materials as ordinary semiconductors, i.e., as resistive elements, selective molecular and morphological design can make all sorts of modulation possible. We can presumably look forward to surface-active semiconductors, or to frequency-, photo-, phono-, magneto-, chemi-, piezo-, or fatigue-modulated semiconductors. The great degree of anisotropy possible in organic semiconductors may be particularly useful.

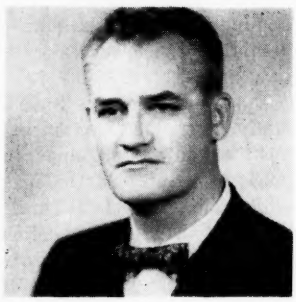
There seems to be no firm assurance either that someone will not succeed in making an organic compound become superconductive. One can also conceive of useful material having selected electro-, actino-, phono-, piezo-, magneto- or thermo-luminescence.

Eventually, all or most of these devices and uses will become a reality. Part of the success will be due to basic discoveries and fresh new ideas stemming from work on organic semiconductors.

References

1. Pohl, H. A., "Semiconduction in Polymers "(A Review), Plastics Laboratory Technical Report No. 61D, Princeton U. (1961).
2. "Modern Aspects of the Vitreous State," Vol. II, ed. by J. D. Mackenzie (Chap. on Semiconduction in Polymers by H. A. Pohl), Butterworths, in press.
3. (a) Nelson, R. C., *J. Chem. Phys.*, **19**, 798 (1951). (b) cf. Conference on Electronic Conduction in Organic Solids, Duke Univ., April 21, 1960.
4. Rust, J. B., Haack, F. A., and Nolta, J. P., WADD Tech. Report 60-111, Oct. 1959 (Hughes Research Labs., Culver City, Calif.).
5. Kearns, D. and Calvin, M., *J. Chem. Phys.*, **29**, 950 (1958).
6. Kearns, D., Tollin, G., and Calvin, M., ibid. **32**, 1020 (1960).
7. Akamatsu, H., Inokuchi, H., and Matsunaga, Y., *Bull. Chem. Soc., Japan*, **29**, 213 (1956).
8. Holmes-Walker, W. A., and Ubbelohde, A. R., *J. Chem. Soc.*, p. 720, 1954.
9. Elsey, D. D., and Spivey, D. I., *Trans. Faraday Soc.*, **56**, 1432 (1960).
10. Labes, M., Sehr, R., and Bose, M., *J. Chem. Phys.*, **32**, 868 (1960).
11. McNeill, R. and Weiss, D. E., *Proceedings of the Fourth Conference on Carbon*, p. 281, Pergamon Press (1960).
12. Pohl, H. A., Bornmann, J. A., and Itoh, W., *Semiconducting Polymers*, Plastics Laboratory Technical Report 60C, Princeton U. (1961).
13. Akamatsu, H., ibid ref. (3b).
14. Epstein, A. and Wildi, B. S., *J. Chem. Phys.*, **32**, 324 (1960).
15. Felmayer, W. and Wolf, I., *J. Electrochem. Soc.*, **105**, 141 (1958).
16. Bohrer, J. G., *Trans. N. Y. Acad. Sci.*, **20**, 367 (1958).
17. Riehl, N., *Kolloid-Z.*, **151**, 66 (1957).
18. Kepler, R. G., Bierstedt, P. E., and Merrifield, R. E., *Phys. Rev. Letters*, **5**, 503 (1960).
19. Pohl, H. A., ed., *Semiconduction in Molecular Solids*, Proceedings of the Princeton U. Conf., Feb. 1960, Ivy-Curtiss Press (1960).
20. Klein, C. A., "Electrical Properties of Pyrolytic Graphites," Raytheon Co., Tech. Rept. R-58, Feb. 21, 1961.
21. Pohl, H. A., ref. 11, p. 241.
22. Pohl, H. A., and Laherrere, J. P., ibid, p. 259.
23. Pohl, H. A., and Laherrere, J. P., ref. 19, p. 93.

Meet the Author



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Chemical Kinetics–Expanding Field

The activated-complex theory, and the use of isotopes and radical reactions have led to broader understanding of chemical kinetics. This increased scope will, however, lead to more specialization.

MARTIN KILPATRICK, *Argonne National Laboratory*

Since I last reviewed the field ten years ago,[1] research in chemical kinetics has expanded greatly. Now, the kineticist's interest varies from the effect of concentration and temperature on reaction rate to detailed mechanisms where kinetic measurements themselves play only a minor role.

The kineticist must interest himself in the determination of molecular species, solvation, hydrogen bonding, acidity constants, free radicals, isotope effects, and the identification of products and intermediates by such techniques as spectroscopy and chromatography.

Let us begin with the familiar Arrhenius equation:

$$k = A \exp(-E/RT) \tag{1}$$

where the parameters A and E (the pre-exponential factor and activity energy, respectively) can be determined by measuring the specific rate constant k over a range of temperature. Precise determination of k over an accurately known temperature interval is required to detect a change of E with temperature, and a small change in E involves considerable variation in A. This equation is adequate for data on uncomplicated gas reaction and most kinetic data in solution.

The theoretical expression for a bimolecular reaction from statistical mechanics is

$$\frac{d \ln k_2}{dT} = \frac{E_z + \frac{1}{2}RT}{RT^2} \tag{2}$$

where E_z is the difference between the average energy of the reacting complexes and the average energy of all colliding pairs of molecules of kinds 1 and 2.

In the transition-state theory, attention is focused on the configuration of the highest energy state. If V_o is the potential energy,

$$k = \kappa \frac{kT}{h} \frac{Q\ddagger}{Q_1 Q_2} \exp(-V_o/kT) = \kappa \frac{kT}{h} K\ddagger \tag{3}$$

where the Q's are combined partition functions for each kind of energy, κ is a transmission coefficient, kT/h a frequency factor, and $K\ddagger$ is the equilibrium constant for the formation of the activated complex from the reactants. If we define the free energy of activation as

$$\Delta F\ddagger = -RT \ln K\ddagger \tag{4}$$

and the entropy of activation as

$$\Delta S\ddagger = \frac{\Delta H\ddagger - \Delta F\ddagger}{T} \tag{5}$$

we have

$$k = \kappa \frac{kT}{h} \exp(-\Delta F\ddagger/RT) \tag{6}$$

and

$$k = \kappa \frac{kT}{h} \exp(\Delta S\ddagger/R) \exp(-\Delta H\ddagger/RT) \tag{7}$$

Eqs. (6) and (7) are useful in interpreting and correlating experimental data. The transition-state theory involves many degrees of freedom and also calculation of the number of molecules in the activated complex, which has one less degree of freedom because of the reaction coordinate. The transmission coefficient is unknown but is usually assigned a value of unity. The reactant entropies are known, but $\Delta S\ddagger$ must be calculated by analogy to known compounds, from tables of thermodynamic properties of chain hydrocarbons where terms for entropy due to C-H vibrations, CH_3 rotations, etc., are available.

Pre-exponential factors for the most detailed form of the activated complex theory (Eq. 3), requiring evaluation of all partition functions of reactants and complex, have been calculated for twelve bimolecular gas-phase reactions,[3] and compared with results by the hydrocarbon analogy (Eq. 7) and the simple collision theory (Eq. 2). Agreement with experimental results was within one order of magnitude in eleven out of twelve cases using partition functions, and within two orders of magnitude using the hydrocarbon analogy. Collision-theory values are higher than experiment by a factor of 10 by 10^3, thus requiring "normal" steric factors.

Cross-combinations of radicals closely approach the collision frequencies. Hydrogen-atom abstrac-

tions, such as the attack of methyl radicals on primary, secondary and tertiary hydrogens in hydrocarbons, show activation energies of 2.3 kcal./mole greater for primary than for a secondary hydrogen, which in turn is 0.6 kcal. greater than for tertiary hydrogens.[4] For electron abstraction, 0.7 kcal./mole more energy is required.

Studying Fast Reactions

Perhaps the most striking development in kinetics has been the expanded resolution of the time scale, especially for reactions in solution. This has been made possible first by improved mixing techniques in flow systems and, when the limit was reached for initiation of reaction by mixing, by new methods where the reaction is rapidly displaced away from equilibrium and the return process followed, or by competition methods with some physical process whose time constant is known.

Flow Method—In order to use this method, the process must be initiated in a time shorter than that for the reactants and products to reach a point of observation.

By following fast absorbency changes with a microspectrophotometer, as little as 10^{-20} moles of intermediates with half-lives of a few seconds have been detected. This accomplishment opens new possibilities in our understanding of kinetics because it is the unstable rather than the stable intermediates that are involved in the reaction path.

Other advances are: application of the Rankine[5] balance, recording of rapid changes in magnetic susceptibility, and oscillographic recording of visible and ultraviolet absorption spectra of short-lived intermediates. Short-lived intermediates have also been detected by spin resonance methods in combination with flow methods.[6]

Inorganic reactions have also been studied by the flow method and the recent isotopic exchange method.[44] In spite of the fact that mixing time (1-2 millisec.) limits the former, second order velocity constants of 10^6 l./mole/sec. are measurable with dilute solutions, and improvement in sensitivity may extend the range. However, for pure liquids or concentrated solutions,[45] rapid mixing of mutually soluble liquids presents cavitation,[46] flow and temperature problems.

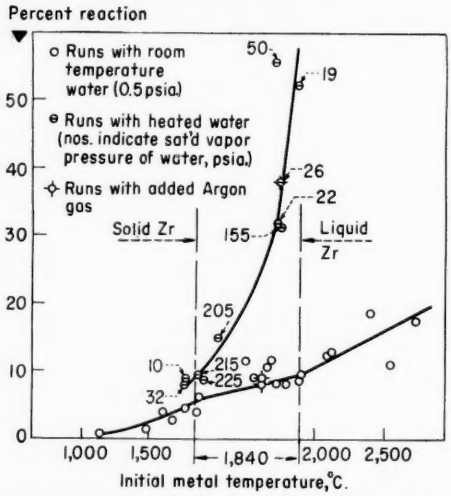
Perturbation Methods—These methods, developed by Eigen[7] and others, avoid the time limitations of mixing. If one has a system at equilibrium or in a steady state, the rapid change of an external parameter such as electrical field strength, temperature or pressure will displace the equilibrium, and the return to equilibrium will proceed with a definite time lag that can be observed directly or indirectly.

Using the dissociation field effect, the velocity constant for the neutralization[8]

$$H^+ m(H_2O) + OH^- n(H_2O) \rightarrow (H_2O)_l$$

has been found to be 1.5 x 10^{11} l./mole/sec.

The temperature-jump method has been applied to oxidation-reduction and to protolytic reactions, using spectrophotometric methods to follow the reaction.[9, 10] The pressure-jump method was developed by Ljungren and Lamm[11] and applied to the carbon dioxide-water system, using variation of conductance with time, after a rapid pressure rise of about 100 atmospheres. The temperature rise is 2-3 deg. per 100 atm., and relaxation can be followed by temperature changes. Spectrophotometric or dielectric-constant methods could also be used to follow the shifting equilibrium. Other methods include the use of sound waves and flash photolysis.[12]



Typical results of experiments with metal-water reactions.—Fig. 1

Competition Methods—Determining rate constants by competition between chemical reactions is well known, but in this case the competition is with a physical property whose time constant is known. These properties include transport processes, such as diffusion or ionic migration, and the techniques involve polarographic,[13] galvanistic,[14] and potentiostatic[15] methods.

Other approaches are to measure the energy input required to maintain a stationary state in photochemical processes, or to determine rate constants by competition with the known lifetime of an excited molecule by fluorescence studies.[16] Electron spin resonance[17] and nuclear magnetic resonance[18] have also been applied to the determination of rate constants, based on line broadening.

Metal-Water Reactions

When two liquids are not mutually soluble but react rapidly on contact, the problem of contacting is somewhat different from that discussed for homogeneous reactions. The problem arises with liquid

propellants where an oxidant and fuel are rapidly contacted, and with hypergolic mixtures where ignition on contact is involved.

A similar problem arises in the reaction of a liquid metal, such as sodium-potassium alloy, with water in the presence or absence of oxygen. Kilpatrick, Baker and McKinley[19] developed a rapid contacting device and found that sodium-potassium alloy reacted with water without ignition in the absence of oxygen, but with delayed ignition in its presence.

Interest is high in reactions of molten metals with water because a destructive power excursion in a water-cooled nuclear reactor could cause melting of the core.

In one study at the Argonne National Laboratory,[20] rapid heating of metal wires underwater was accomplished by a surge current from a bank of condensers. The energy input was used to calculate initial reaction temperature, and the reaction rate was determined with pressure transducers. Completion of the reaction required a few milliseconds, and the total extent was determined by analysis for hydrogen.

Fig. 1 shows some typical results. The lower curve is the result for hot zirconium particles (or wire) with water initially at room temperature (vapor pressure 0.5 psia.). The upper curve is the result with heated water (90-200 C. vapor pressure, 10-225 psia.). Numbers on the graph show pressure. Although there is a difference in rate between water at room temperature and water at 90 C., there is no further difference up to 200 C. The presence of inert gases gives no detectable effect. The fact that the extent of reaction does not increase regularly with pressure is interpreted to mean that the reaction is controlled initially by the rate at which water vapor reaches the metal surface (the rate falling off as the vapor pressure becomes very low) and, at a later stage, by processes occurring within the oxide film.

The two-step reaction is explained as follows: The condenser discharge heats the metal wire to a high temperature in about 0.3 milliseconds. The wire, if heated above its melting point, rapidly forms approximately spherical particles, which are almost instantaneously surrounded by a film of hydrogen and steam. The first stage of the reaction is then controlled by the diffusion rate of water vapor at T_w, to the metal surface at T_s, and the diffusion of hydrogen away from the surface. The reaction is eventually controlled by the diffusion rate of metal or oxide ions through the oxide film, this rate being inversely proportional to the thickness of the film. It is thickening of the oxide layer that causes the solid-state processes to become slower than the gas-phase processes and hence, rate determining. The decreasing rate of solid-state diffusion eventually allows the particles to cool, and the reaction stops short of completion.

Reaction of the larger metal particles required about 0.1 sec. to reach a final value. There appears to have been a central particle size (0.5-mm. diameter for room temperature water and 1 mm. for heated water) below which a very rapid reaction occurred, the final value being reached in a few milliseconds. These particles are propelled rapidly through the water by the evolving hydrogen, causing a great increase in the rate of the gaseous diffusion process.

We concluded that the melting of zirconium-clad fuel elements in a nuclear reactor would add some heat and hydrogen gas to an already serious incident but would not constitute a major hazard unless very fine particles were formed in large amounts.

Chain Reactions

So far, we have discussed reactions of integral order, but there is another class of reaction that rarely shows simple order. Chain reaction usually takes place homogeneously in the gaseous or liquid phase, and is frequently initiated by a unimolecular reaction that gives an active center, such as an atom or free radical, which reacts further to give more active centers. Propagation continues until the reactants are consumed or the chain is stopped by a termination step. The chemical energy set free in the elementary step is partially spent in the formation of intermediate products still having considerable energy. The reiterated process constitutes a chemical chain.

Initiation—The initiation step can be homogeneous and can be brought about by thermal, photo or other radiation-induced decomposition of a reactant at the wall or on the surface of a solid catalyst, such as a colloidal metal, or by the addition of a proton from a siliceous clay. The active center may propagate the chain into the gas phase so that the reaction occurs homogeneously after initiation. Still another method is the introduction of atoms such as H, O or Cl by dissociating the molecules in an arc.

Propagation—Initiation is followed by reiterated steps where atoms, free radicals or highly activated molecules react with reactants to yield products and one or more chain centers. The energy of activation should be low enough or the entropy high enough that, in competition with the chain termination step, the propagation reaction repeats itself and does not become a simple series of consecutive reactions.

Termination—Here, destruction of the reaction centers by energy transfer through collision caused by charge neutralization and recombination brings about termination. Collision can be with other molecules or, particularly in gas reactions, with the walls.

To illustrate, let us take simple addition polymerization, oxidation of hydrogen and oxidation of hydrocarbons.

Polymerization—The over-all reaction[21]

$$m_i \rightarrow \frac{1}{n}\, m_n$$

consists of an initial step $m_i \xrightarrow{k_i} m_i^*$

a propagation step $m_i + m_j^* \xrightarrow{k_p} m_{j+1}^*$

and termination steps (linear) $m_j^* \xrightarrow{k_t} m$

or mutual $m_i^* + m_j^* \xrightarrow{k_t} m_{i+s}$

where the asterisk denotes a polymer species capable of reacting with the monomer to form another reactive center. In the formation of dimers, trimers and tetramers, the velocity constants of propagation would be different, but as longer chains form, the velocity constant is independent of chain length,[22] and

$$-\frac{d[m_i]}{dt} = k_p[m_i]\sum_{1}^{\infty}[m_j^*]$$

Initially, $[m_i]$ can be considered constant, and the remainder of the expression is determined by the initiation and termination reactions.

Hydrogen-Oxygen Reaction—In the oxidation of hydrogen to form water vapor, the stoichiometric mixture's explosion limits depend on temperature and pressure. The reaction is also very sensitive to traces of foreign gases and to the nature of the vessel walls. The reaction can be initiated by the introduction of hydrogen or oxygen atoms, and hydrogen peroxide has been formed at low temperature. Studies by Semenoff[23] and Hinshelwood[24] show that enough basic information is available to use this fuel-oxidant system as a propellant.

Many workers have established the chain propagation steps, and Semenoff's reaction scheme and mechanism[25] fit both theory and experiment at sufficiently high temperature.

Initiation:	$H_2 + O_2 \rightarrow H + HO_2 - 55$ kcal	0
	$H_2 + O_2 \rightarrow 2OH - 15$ kcal.	0
Propagation:	$OH + H_2 \rightarrow H_2O + H + 14$ kcal.	1
and branching:	$H + O_2 \rightarrow OH + O - 15$ kcal.	2
	$O + H_2 \rightarrow OH + H + 0$ kcal.	3
Termination:	OH + wall; H + wall; O + wall	

Chain initiation, if it is homogeneous, should be very slow—the velocity constant being 10^{-22} at 800 K.—but once this trigger mechanism starts, the reaction is complete in a few tenths of a second.

The velocity constants in the range 600-800 K. for homogeneous propagation and branching are given in units of cc./molecule/sec., with

$$k_1 = 2 \times 10^{-10} \exp(-10{,}000/RT)$$
$$k_2 = 0.94 \times 10^{-10} \exp(-15{,}100/RT)$$
$$k_3 = 2 \times 10^{-10} \exp(-6{,}000/RT)$$

The termination steps depend on the diffusion of the radicals to the wall and the adsorption kinetics.

Oxidation of Hydrocarbons—This can be represented by the following sequence:[26]

Initiation: $RH + O_2 \xrightarrow{0} ROOH$

$2ROOH \xrightarrow{1} R + RO_2 + H_2O$

Propagation: $R + O_2 \xrightarrow{2} RO_2$

$RO_2 + RH \xrightarrow{3} ROOH + R$

Termination: $RO_2 + RO_2 \xrightarrow{4} ROOR + O_2$

The steady-state rate of oxidation for this is

$$-\frac{d[O_2]}{dt} = \frac{k_3^2[RH]^2}{k_4}$$

Both understanding of the role of organic peroxides in paraffin halogenation and the development of an organic chemistry of free radicals in solution[27] consistent with gas-phase chemistry have developed rapidly since 1946 and are now of major industrial importance in the manufacture of phenol, hydrogen peroxide and polymers. Semenoff gives the general treatment of radical reactions.[25]

Isotope Effects

Initially, isotopes were used as "tagged atoms" or tracers. Recent work shows, however, that studying the magnitude of kinetic isotope effects and the effect of temperature on rates definitely indicates the elementary steps in many reactions. This is particularly true of hydrogen isotopes, where the effect is greatest.

Radioactive isotopes are also useful in kinetics as analytical tools. For example, the precision of counting techniques is such that a very slow reaction tagged with tritium can be followed over a very small part of the initial stage, and velocity constants can be accurately determined—or a very fast reaction can be followed accurately at the end. The kinetic effects can be divided into two classes, primary and secondary, as well as a third, or solvent, effect.

Primary Effects—These are defined as the ratio of the rates when the rate-controlling step involves the rupture or formation of a bond involving the isotope. For reactions involving a C-C bond, the effect is less than 10% and there is fair agreement between experiment and theory. For heavier atoms, the effects are smaller—about 5% for S^{32}-S^{35} and 2% for I^{127}-I^{131} Experimentally, the effect with C^{12}-H and C^{12}-D bonds varies from 1.4 to 16, while the calculation of the partition function for Eq. (3) in its simplest form gives 7 at 25 C., corresponding to a net difference in activation of 1.15 kcal./mole, with more-sophisticated calculations giving smaller effects.

The zero-point energies for stretching vibrations for N-H and N-D give 1.27 kcal./mole, corresponding to a $\Delta E_o/RT$ at 25 C. of 8.5 and 1.40 kcal./mole for O-H and O-D, respectively.[28]

The major contribution to the kinetic-isotope effect lies in the loss of the A-H stretching frequency in the transition state. The isotope effect should then show up as a difference in activation energy rather than a difference in the pre-exponential factor, the limits being $\frac{1}{2}$ to 1.4.

Values of A_H/A_D much smaller than 0.5 have been found for the hydrogen-isotope effect in the bromination of 2-carbethoxycyclopentanone catalyzed by fluoride ion in the solvent deuterium oxide.[47] This is attributed to the tunnel effect. The fact that $k_H/k_D <$ 6 for many reactions involving the breaking of a C-D bond has been discussed in terms of the "activated complex."[48]

Secondary Effects—These can be defined as effects due to substituting an isotope in a reacting molecule in a position not involved in bond rupture or formation for the reaction under study. This effect will be small and will vary with the position of substitution.[29] What might be called a secondary effect is found when

OD^- instead of OH^- is receiving a proton, or H_2O instead of D_2O, in a generalized base-catalyzed reaction. OD^- is a more effective base catalyst than OH^- by 20% and H_2O is more effective than D_2O by 30-40%.

Solvent Effects—Even if the solvent does not formally enter the reaction scheme, a change of solvent, say from H_2O to D_2O, may affect the reaction velocity. This effect can amount to 40% and is said to be due to differences in structure between the solvents.[30]

Examples of this effect are the hydrolysis of organic halides and sulfonates[31] where the hydrolysis in H_2O is from 6-30% faster than in D_2O, and in bromination of ketones by anion bases[32] where the effect is 20-40% faster in H_2O than in D_2O. These effects must be due to differences in hydrogen bonding or solvation.

For reactions showing no general acid catalysis, we have cases such as the inversion of sucrose and the hydrolysis of acetal and diazoacetic ester[33] where $k_D/k_H > 1$. These reactions are characterized by large primary kinetic salt effects and a change in the energy of activation with temperature.[34] Pre-equilibrium between the substrate and the solvated proton[35] appears to be the explanation, but the role of hydrogen bonding in the kinetics of acid-base catalyzed reactions needs further study.

Nitration and Sulfonation

In the fields of nitration and sulfonation, technology has moved ahead faster than basic research. It is now generally accepted that nitronium ion NO_2^+ is the nitrating species, and the kinetics and mechanism of aromatic nitration have been clarified by the Ingold School.[36] For sulfonation by sulfuric acid, there is still not general agreement on the sulfonating species in vitriol or oleum, but a rate law for sulfonation in vitriol has been established.[37, 38]

The function of sulfuric acid in "mixed acid" nitration is to provide a highly acidic medium so that nitric acid, nitrogen pentoxide, dinitrogen tetroxide, ethyl nitrate, acetylnitrate and benzoyl nitrate, all bases in this solvent, can react to form nitronium ion. Any other acid of high proton availability,[39] such as perchloric or hydrogen fluoride, should serve instead of sulfuric and, in the case of covalent fluorides that act as fluoride ion acceptors in HF, the addition of BF_3, NbF_5 or others should further increase the reaction rate by increasing NO_2^+ concentration. The halide acceptor should play the same role as in Friedel-Crafts processes but complications might result from halogenation.

For reactive aromatics such as benzene and toluene, the reaction is zero order in the concentration of aromatic hydrocarbon. To compare reactivities of aromatics, Hughes and Ingold secured dependence on the concentration of the hydrocarbon by dilution with water, acetic acid or acetic anhydride, or by carrying out the reaction in nitromethane. They found relative reactivities for toluene/benzene of approximately 25, from which partial rate factors can be calculated if isomer distribution is known.[40]

Another approach to relative reactivities is to prepare an anhydrous nitronium salt and carry out nitrations where the rate-determining step could not be the formation of nitronium ion. Olah and co-workers[41] prepared nitronium salts and used $NO_2^+BF_4^-$ dissolved in tetramethylene sulfone to carry out competitive nitrations of alkylbenzenes to determine isomer distributions.[42] However, they found relative reactivities of toluene to benzene of 1.67 and reached the conclusion that π and not σ complex formation is the main rate-determining step. If the reaction is between π electron systems and not between individual positions, partial rate factors and selectivity rules would appear to be of no significance.

Research Through Development

In laboratory kinetic studies, the batch-type experiment yields more information than does the continuous. This information is usually in the form of a rate law that gives the reaction order in terms of the stoichiometric concentration of each reactant, with the effect of temperature on the rate.

Although these laboratory data form the basis for a pilot plant, the chemical engineer often finds it difficult to translate them into a continuous process that will afford the necessary design data. Better design data can be made available if the engineer will carry out a few well-chosen experiments in simple laboratory-scale reactors of the continuous-flow stirred-tank type.[43] In contrast to the batch process, where the system changes with time, a stationary state is maintained by adjusting flow rates. To maintain a steady state, mixing must be fast compared with the reaction rate. For a reaction $A + B$ to give $C + D$, the steady-state condition is

$$\frac{d[A]}{dt} = \frac{d[B]}{dt} = \frac{d[C]}{dt} = \frac{d[D]}{dt} = 0 \qquad (8)$$

where the brackets represent molar concentration. If u is the flow rate, the quantity of C leaving the reactor per unit time is $u[C]$—the rate of formation of the product C. If V is the reactor volume, the velocity constant of the reaction is

$$\frac{u[C]}{V} = k[A]^n[B]^m \qquad (9)$$

The order of the reaction can be found by determining the variation in concentration of C caused by variations in concentration of A and B, and can be compared with the results of the batch process, where

$$t = \frac{1}{k}\int \frac{d[C]}{[A][B]} \qquad (10)$$

For autocatalytic or chain reactions, the differential equation of the batch process can be complicated, and the integral not always easy to evaluate. But as

Eq. (9) does not contain an integral, the order can be determined simply, provided the stationary state is maintained. Disadvantages of the flow method compared with the batch method for research are that each stationary state yields only one point, and establishment of the steady state takes time.

The single-compartment constant-flow stirred reactor is not suitable for plant-scale applications but is quite useful in the study of the parameters necessary for design of a multistage reactor.

Mathematical consideration of conversion and output is given by Denbigh,[43] together with a comparison of batch and tubular reactors. In my opinion, the chief advantage of the CFSTR reactor is the opportunity to translate research batch results into design data, to study further the effect of the various parameters and to obtain control data for the future plant.

These reactors can be constructed of glass, and the various sizes set up as permanent installations in the laboratory. For highly exothermic reactions, heat-transfer problems can be solved, and the advantages of adding reactants or initiators at different rates for reactions of different orders can be clarified.

The Literature Problem

Twenty-five years ago, there were three groups of kineticists—those interested in homogeneous gas reactions, another group interested in heterogeneous catalysis and a third in homogeneous reactions in solution. Today we have kineticists in so many areas, and such a variety of new techniques exist that, by 1970, workers in one area will be unfamiliar with any other and may even talk a different kinetic language.

In any case, the literature will be so vast it may even be impractical to keep up to date in one's own area. The thermodynamicist has his tables but the kineticist has no handbook of rate factors.

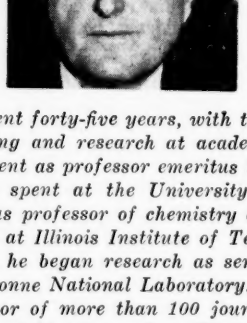
In anticipation of this problem, the National Bureau of Standards, the Committee on Tables of Constants of the National Research Council and Princeton University sponsored the compilation of kinetic data for homogeneous systems, and published a 731-page circular in 1951. The work was subsequently supported by the Office of Ordnance Research and, in 1952, a 472-page supplement was published, with an index for the whole in 1960. A second supplement is in press,

These publications are limited in scope and have continually fallen behind the current literature. The Advisory Committee on Chemical Kinetics of NRC is now considering a more sophisticated approach.

References

1. Kilpatrick, M., *Ann. Rev. Phys. Chem.*, **2**, 255-286 (1951).
2. Glasstone, S., Laidler, K. J., Eyring, H., "The Theory of Rate Processes," McGraw-Hill, New York, 1941.
3. Herschbach, D. R., Johnston, H. S., Pitzer, K. S., Powell, R. E., *J. Chem. Phys.*, **25**, 736 (1956).
4. Rice, F. O., Vanderslice, T. A., *J. Am. Chem. Soc.*, **80**, 291 (1958).
5. Rankine, A. O., *Proc. Phys. Soc.*, **46**, 391 (1934).
6. Wertz, J. E., Vivo, J. L., *J. Chem. Phys.*, **23**, 2441 (1955).
7. Eigen, M., *Discussions Faraday Soc.*, **24**, 24 (1957).
8. Eigen, M., De Maeyer, L., *Z. Elektrochem.*, **59**, 986 (1955).
9. Czerlinski, G., Eigen, M., *Z. Elektrochem.*, **63**, 652 (1959).
10. Czerlinski, G., Diebler, H., Eigen, M., *Z. Physik. Chem.*, **19**, 246 (1959).
11. Ljungren, S., Lamm, O., *Acta Chem. Scand.*, **12**, 1834 (1958).
12. Porter, G., *Z. Elektrochem.*, **64**, 59 (1960).
13. Kortya, J., *Z. Elektrochem.*, **64**, 23 (1960).
14. Gierst, L., Hurwitz, H., *Z. Elektrochem.*, **64**, 36 (1960).
15. Gerischer, H., *Z. Elektrochem.*, **64**, 29 (1960).
16. Weller, A., *Z. Elektrochem.*, **64**, 55 (1960).
17. Weissman, S. I., *Z. Elektrochem.*, **64**, 47 (1960).
18. Meiboom, S., *Z. Elektrochem.*, **64**, 50 (1960).
19. Kilpatrick, M., Baker, L., McKinney, C. D., Jr., *J. Amer. Chem. Soc.*, **57**, 385 (1953).
20. Baker, L., Jr., Warchal, R. L., Vogel, R. C., Kilpatrick, M., *Argonne Nat. Lab. Report* 6257.
21. Dainton, F. S., "Chain Reactions," Methuen and Co., London (1956).
22. Burnett, C. M., Melville, H. W., *Proc. Roy. Soc.*, **A189**, 456 (1947).
23. Semenoff, N., "Chemical Kinetics and Chain Reactions," Clarendon Press, Oxford (1933).
24. Hinshelwood, C. N., Williamson, A. T., "The Reaction Between Hydrogen and Oxygen," Clarendon, Oxford, (1934).
25. Semenoff, N. N., "Some Problems of Chemical Kinetics and Reactivity," (1954) translated by Boudart, M., Princeton University Press (1958). Also translated by Bradley, J. E. S., Pergamon, New York (1958).
26. Tobolsky, A. V., Metz, D. J., Mesrobian, R. B., *J. Amer. Chem. Soc.*, **72**, 1942 (1950).
27. "Vistas in Free Radical Chemistry," ed. by Waters, W. A., Pergamon, New York, (1960).
28. Bell, R. P., "The Proton in Chemistry," Cornell University Press, Ithaca, N. Y., (1959).
29. Wiberg, K. B., *Chem. Rev.*, **55**, 713 (1955).
30. Swain, C. G., Bader, R. F. W., *Tetrahedron*, **10**, 182 (1960).
31. Robertson, R. E., Laughton, P. M., *Can. J. Chem.*, **35**, 1319 (1957).
32. Long, F. A., Watson, D., *J. Chem. Soc.*, 2019 (1958).
33. Roginsky, S. Z., "Theoretical Principles of Isotopic Methods for Investigating Chemical Reactions," Academy of Science, U.S.S.R. Press, Moscow (1956).
34. Kilpatrick, M., "Handbuch der Katalyse," ed. by Schwab, G. M., pub. by Springer, Julius, Vienna (1940) Vol. II, 249-271.
35. Bonhoeffer, K. F., *Trans. Faraday Soc.*, **34**, 252 (1938).
36. Gillespie, R. J., Miller, D. J., *Quarterly Rev.*, **2**, 277 (1948).
37. Kilpatrick, M., Meyer, M. W., Kilpatrick, M. L., *Phys. Chem.*, **64**, 1433 (1960).
38. Kilpatrick, M., Meyer, M. W., *J. Phys. Chem.*, **65**, 530 (1961).
39. Kilpatrick, M., *J. Chem.*, **37**, 403 (1960).
40. de la Mare, P. B. D., Ridd, J. H., "Aromatic Substitutions," Academic Press, New York, pp. 79-93 (1959).
41. Olah, G., Kuhn, S. J., Mlinko, A., *J. Chem. Soc.*, 4257 (1956).
42. Olah, G. A., Kuhn, S. J., Flood, S. H., unpublished work.
43. Denbigh, K. G., *Trans. Faraday Soc.*, **40**, 352 (1944).
44. Wahl, A. G., *Z. Elektrochem.*, **64**, 90 (1960).
45. Baker, L., Jr., Kilpatrick, M., "5th Symposium on Combustion, Reinhold," New York pp. 196-205 (1955).
46. Chance, B., *J. Franklin Inst.*, **299**, 455 (1940).
47. Bell, R. P., Fendley, J. A., Hulett, J. R., *Proc. Royal Soc.*, **A235**, 543 (1956).
48. Westheimer, F. H., *Chem. Rev.*, **61**, 265 (1961).

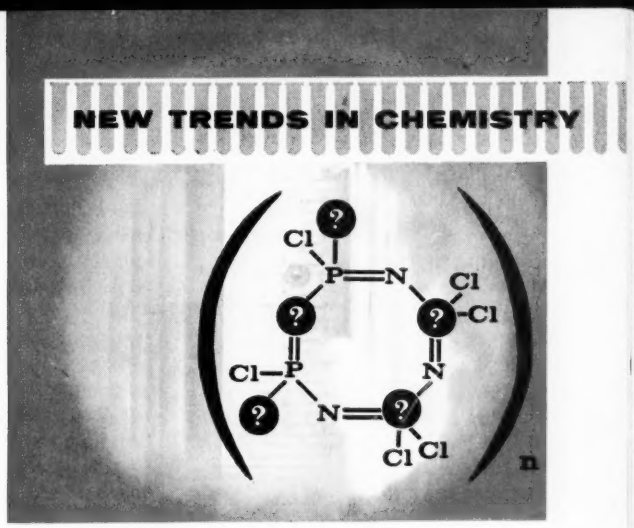
Meet the Author



MARTIN KILPATRICK *spent forty-five years, with time out for two wars, in teaching and research at academic institutions until his retirement as professor emeritus last year. Nineteen years were spent at the University of Pennsylvania, and thirteen as professor of chemistry and chairman of the department at Illinois Institute of Technology. In the fall of 1960, he began research as senior chemist emeritus at the Argonne National Laboratory.*

Dr. Kilpatrick is the author of more than 100 journal articles, chiefly in the fields of kinetics and equilibria in aqueous and nonaqueous solutions. In 1953, he was a Fulbright Research Scholar in Europe.

Although work is in an early stage, important advances have been made in developing new polymers with the heat resistance of inorganic materials and the pliability of organics.



Inorganic-Polymer Chemistry Points Way to High-Temperature Plastics

G. BARTH-WEHRENALP, *Research and Development Dept., Pennsalt Chemicals Corp.*

In recent years, there has been considerable interest in inorganic polymers, mostly sparked by the need for new materials capable of withstanding high temperatures.

Much of this need has been created by fast advancing space-age technology with its rigorous performance requirements that presently available plastics cannot meet. There is no question that there is a large potential market—military and civilian—for plastics that will maintain their useful properties when exposed to high temperatures.

Except for the silicones, all plastics used today are organic, with carbon-containing backbones. While inorganic materials, in general, are much more resistant to heat than organic materials, most inorganics are difficult to work because of their brittleness and rigidity. It is, therefore, not surprising that chemists have turned their attention to the search for inorganic polymers—hoping to combine the heat-resistant properties of inorganic chemicals with the workability of organic plastics.

Inorganic-polymer research is in its early stages. Although important advances have been made, a considerable amount of additional research, mostly basic, will probably have to be done before inorganic, high-molecular-weight materials with useful properties can be tailor-made.

This article will review the present status of this field. Naturally, it will be impossible to do justice to the work of everyone. Instead, I will try to point out (using a number of typical examples) the directions research is taking. I will also discuss typical problems that need solving and some of the significant advances made to date. For clarity, simplifications will be made in some cases. However, the over-all picture will not be distorted.

What Are Inorganic Polymers?

An inorganic polymer can be defined as one that does not contain carbon-to-carbon bonds in its backbone. Quite often, polymers with inorganic backbones also contain organic groups and are referred to as semi-inorganic or semi-organic. As will soon become apparent, many of the systems we will discuss belong in this class. However, in accordance with the above definition, such systems will be considered inorganic polymers.

There are a number of inorganic substances—elements as well as compounds—that are polymeric and have well-known elastomeric or at least plastic properties.

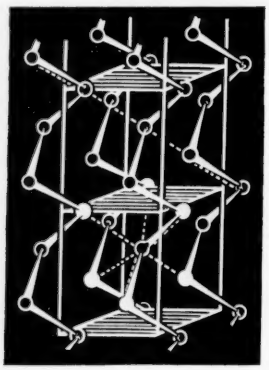
For example, a form of sulfur that is elastomeric (rubber-like) can be obtained by rapid cooling of molten sulfur. It most likely consists of long chains of interconnected sulfur atoms.

Strong,[1] Meyer[2] and Sakurada[3] first studied the elastomeric properties of this polymeric sulfur, which is usually called plastic sulfur. As with unvulcanized rubber, it is difficult to obtain reproducible quantitative data since even small stresses cause plastic flow. Furthermore, plastic sulfur quickly crystallizes under stress.

About ten years ago, Specker[4a] discovered that plastic sulfur can be stabilized by "vulcanization" with small amounts of red phosphorus. Plastic sulfur treated in this way remains stable for many months, making reproducible measurements possible. By extrap-

olation to a zero-phosphorus content, Specker determined the elastic modulus of plastic sulfur and from it calculated a minimum degree of polymerization of 2,000 to 5,000 sulfur atoms.

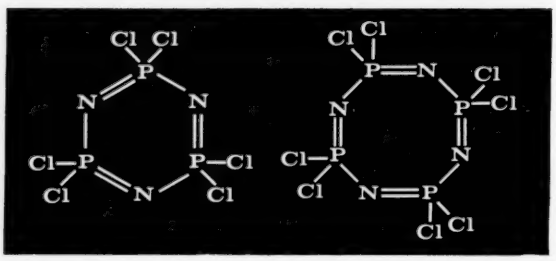
Selenium Forms Chain Polymer



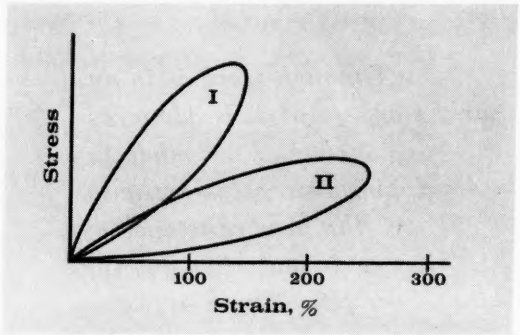
Metallic selenium, the structure of which is shown above, may also be considered a chain polymer. Spiral chains of selenium atoms are arranged along the trigonal axis; distance between atoms of neighboring chains is 50% larger than that between atoms in the chain. The interchain bonds, therefore, will be weaker than the intrachain bonds, and there should be a temperature high enough to break some of the former bonds without destroying the chain. In fact, it has been reported[5] that between 158 and 163 F., rapidly-quenched molten selenium shows rubber-like behavior; below this temperature, it is described as glassy and rather brittle.

Again, there are considerable experimental difficulties in obtaining reproducible data. Jenckel[6] points out that mechanical properties of so-called "glassy" selenium depend very strongly upon the history of the selenium fibers used in the work. More recent work by Specker,[4b] done by compression tests on samples with relatively large cross-sections, indicates that the previously mentioned high elasticity of selenium was not a property typical for the temperature range of 158 to 163 F. At any temperature above 88 F.—the glass transition temperature of selenium—reversible deformation occurs. The temperature of about 158 F. just happens to be a temperature at which the plastic properties of selenium are easily recognized.

Inorganic Rubbers From Phosphonitrilic Cl



Inorganic behaves like a rubber—Fig. 1



Perhaps the most interesting inorganic polymers are the phosphonitrilic chlorides. Since their discovery by Liebig and Wohler[7] about 130 years ago, considerable work has been done on these fascinating compositions. The mechanism of formation and also the structures of these high-molecular-weight polymers, however, are still subject to controversy.

The reaction of phosphorus pentachloride with ammonium chloride at about 260 F. leads to a number of cyclic polymers having the structures indicated (left).

If these cyclic compounds are heated, a high-molecular-weight product forms. This material is highly elastomeric and so strikingly resembles rubber that it is usually referred to as "inorganic rubber."

Back in 1936, the mechanical properties of polymeric phosphonitrilic chloride were studied by Ficquelmont.[8] Different samples gave different stress-strain curves. Polymerization of the trimer, for example, resulted in a less extensible rubber (I) than did polymerization of a mixture of cyclic compounds (Fig. 1). It should be noted that the points determining the curves represent equilibrium values. If equilibrium is not established, rubber (I) properties approach those of (II).

As obtained, the phosphonitrilic chloride rubber is amorphous. But it is completely analogous to organic rubber: it becomes crystalline when stretched, and returns to the amorphous state when stress is released.

It is generally believed that inorganic rubber consists of long chains (see structure as indicated below). Chlorine atoms are represented by X's.

$$PCl_5 + NH_4Cl \longrightarrow \frac{1}{n}(PNCl_2)_n + 4HCl$$

$$\left(-\begin{matrix}X\\P\\X\end{matrix}=N-\begin{matrix}X\\P\\X\end{matrix}=N-\begin{matrix}X\\P\\X\end{matrix}=N-\right)_n$$

However, based on a study of the kinetics of depolymerization, Patat and Derst[9] conclude that polymeric phosphonitrilic rubber consists of statistically interlinked large rings. Size of the rings depends upon the polymerization temperature—the lower this temperature, the larger the ring.

Here we have a departure from the classical theory

of organic polymers that explains the properties of organic elastomers in terms of coiling chains. It is by no means certain that this concept applies to inorganic systems as well.

Because of its insolubility, the molecular weight of inorganic rubber could not be determined. Meyer and co-workers,[10] on the basis of X-ray data, estimate a minimum molecular weight of 20,000. Using a relationship between elastic modulus and molecular weight derived by Kuhn[11] for ideal elastomers, Specker[12] calculated a minimum degree of polymerization of 700 $PNCl_2$-units, corresponding to a molecular weight of 81,000.

Reacts With Water

To date, phosphonitrilic rubber has not found commercial applications, probably because of its reactivity with water. If exposed to atmospheric moisture, the rubber decomposes, with evolution of HCl vapors.

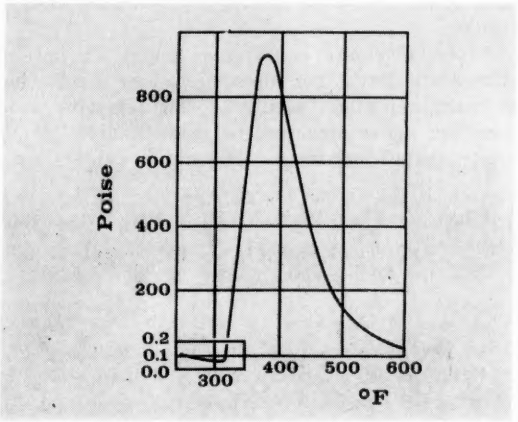
Considerable research has been carried out during recent years in attempts to improve its hydrolytic stability. Phosphonitrilic rubbers have been made with different elements or groups replacing the chlorine atoms, but no high-molecular-weight products with improved resistance to moisture have yet been made.

Perhaps there is another reason why inorganic rubber has not found wide use. It is prepared from trimeric or tetrameric ring compounds which, upon heating, rearrange into rubber. Upon further heating, however, the rubber converts back into these low-molecular-weight cyclic compounds. This degradation starts above 500 F., and at about 750 F. the rubbery properties disappear and we again have the low-molecular-weight rings with which we started.

Inorganics Compared With Organics

We are concerned here with an equilibrium phenomenon that also occurs in plastic sulfur. If sulfur is heated beyond its melting point, the melt exhibits a very striking viscosity behavior, which demonstrates a reversible change in molecular weight. As Fig. 2 shows, the (low) viscosity of molten sulfur decreases up to 314F., as it does for any liquid with increasing temperature. Here, only eight-membered sulfur rings are present. Beyond this temperature, molten sulfur becomes very viscous, indicating that the rings open up and form either long chains or interlocked large rings—in other words, high-molecular weight structures.

Molten sulfur's viscosity—Fig. 2



Quenching from these melts produces the plastic sulfur mentioned before. If molten sulfur is heated to temperatures in excess of 368F., viscosity again decreases with increasing temperature. Now the high-molecular-weight structures depolymerize until finally only eight-membered sulfur rings are present.

A tendency to rearrange at higher temperatures to small-ring compounds is exhibited by all known inorganic elastomers. We may also have to overcome this problem on other structures to arrive at practical high-temperature plastics.

Plastic sulfur, glassy selenium and inorganic rubber are the only wholly inorganic substances that exhibit elastomeric properties at medium temperatures. They prove that it is possible to obtain purely-inorganic high-molecular-weight materials with mechanical properties comparable to those of organic polymers. Consequently, the presence of carbon by no means is a prerequisite for plastic behavior. Once this is established, the question arises as to what other inorganic elements can be used.

Let's assume we are specifically looking for inorganic polymers with thermal stability superior to organic polymers. We will want to choose elements capable of forming strong bonds that will not rupture at high temperatures. Such bonds will allow the polymer to maintain its structure under thermal stresses.

As the table shows, there are a large number of bonds between inorganic elements that are stronger than the carbon-to-carbon single bond:

Bond energies (kilocalories)

Bonds stronger than C-C (83)

C≡N	(213)	N−H	(104)	S=O	(119)
N=O	(145)	Be−O	(109)	B−C	(89)
P=O	(179)	B−O	(124)	Al−Cl	(101)
Si−O	(110)	As−O	(93)	B−H	(93)
Si−Cl	(95)	N−N	(100)	B−F	(150)

But good bond strength alone does not suffice. There are many other factors that will influence stability of the polymer, such as kinetic considerations. It is, therefore, not possible to choose any one combination of elements as best, on the basis of information available today. Consequently, most efforts are directed to obtaining background information on inorganic-polymeric systems by basic studies on already existing systems, as well as by investigations aimed at the synthesis of new polymers.

Bonding between inorganic elements, in general, is much more complicated and less understood than

bonding of carbon. Much research remains to be done before inorganic-polymer chemistry can catch up with the state of knowledge in organic-polymer science. But the rewards will be great once this is accomplished.

Consider the Silicones

At this point, it is appropriate to mention an important group of polymeric materials that contain an inorganic backbone of alternating silicon and oxygen atoms. These materials also all contain organic groups such as CH_3 and C_2H_5 linked to the silicon atoms.

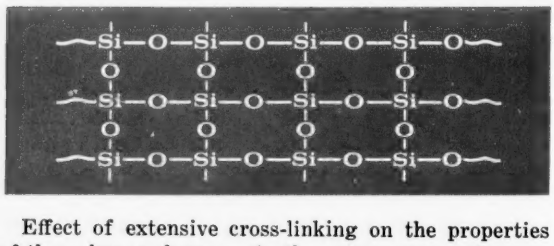
These siloxane polymers—commercially available as silicones—exhibit better thermal stability than organic polymers, but thermal stability depends upon several conditions. If heated in air, the methyl groups on the silicon atoms are seriously attacked at about 400F. They start to oxidize. This effect can be delayed somewhat by addition of certain compounds that act as antioxidants. In the absence of air, silicones can be heated to about 660F., and it is interesting to note that under these conditions the silicon-oxygen bonds start to rearrange to cyclic compounds of low molecular weight. The silicon-methyl bond, in the absence of air, is stable to about 930F.

Polymeric silicones are available today in a large variety; they possess properties that make them useful over a temperature range where organic polymers fail.

Low molecular weight, and therefore liquid, silicone polymers are used as lubricants and hydraulic fluids. They generally show slight temperature-dependence of viscosity, are chemically inert and odorless. Their physical properties (boiling points, freezing points, viscosities) vary over a wide range depending upon degree of polymerization as well as the nature of the organic group connected to the silicon atom.

Silicone rubbers have the same basic structure as the liquid products, but many more units are combined to linear chains that are occasionally cross-linked. Elastomeric properties of the silicone rubbers depend upon the number of such units in the chain and the number of cross-links. The higher the average molecular weight, the higher the elasticity and mechanical strength. On the other hand, only occasional cross-links can be present, or the polymer will lose its elastomeric properties.

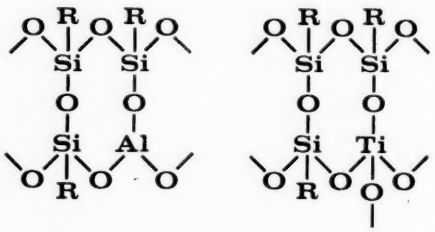
Cross-Linking Gives Rigid Structure



Effect of extensive cross-linking on the properties of the polymer shows up in the extreme case of cross-linking each silicon atom with oxygen. As shown (left), a three-dimensional rigid network is formed, and consequently the useful plastic properties are lost. As a matter of fact, the structure represented here is silica, where separate molecules can no longer be distinguished. Such completely cross-linked structures are plentiful in inorganic chemistry and will not be considered here.

Much work has been, and is being, done on preparation, structures and properties of silicones. No attempt will be made to review this field here, but some recent work on siloxane polymers might lead to products with still better thermal properties.

Andrianov[13] in Russia, has incorporated other metals such as aluminum and titanium into the silicon-oxygen backbone. These polymetallo-organosiloxanes represent a new class of polymers that contain double chains (see below). R here is an organic group.



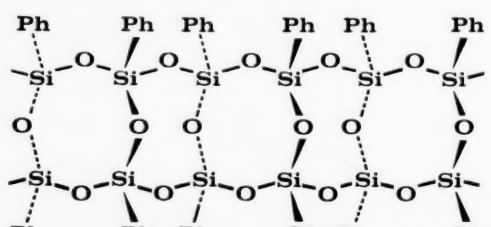
Some of these polymers are reported to be thermally stable, melting above 1,100F. Others are soluble in common organic solvents.

Such ladder-type structures are probably desirable for high thermal stability, because breakdown of one bond does not result in rupture of the polymer chain. Practically no information is available on the mechanical properties of these polymers.

Important Silicone Advances and Analogs

Hornbaker and Conrad[14] attempted to incorporate tin, lead, magnesium, copper, zinc and mercury into the siloxane chain. Although resinous polymeric materials were obtained, the products decomposed rather easily and were definitely less stable than the silicones.

Silicone polymers containing double chains but, unlike Andrianov's, not containing other metals, have also been reported recently[15]. The drawing below shows the linear structure of these soluble "phenylsilsesquioxane" polymers. Molecular weights up to



200,000 have been obtained without branching, and up to 4 million with branching.

In going from silicon to the next element in the fourth group of the periodic table, germanium, we find that polymers analogous in structure to the silicones can be prepared. More recently,[16] the tetramer of dimethylgermanium oxide was again investigated. Unlike its silicon analog, it is very soluble in water, and hydration occurs to form the diol:

$$(Me_2GeO)_4 \xrightarrow{H_2O} Me_2Ge(OH)_2 \underset{+H_2O}{\overset{-H_2O}{\rightleftharpoons}} (Me_2GeO)_x$$

When an aqueous solution of dimethylgermanium oxide evaporates, a white fibrous material forms, presumably by condensation. This reaction is reversible, since the polymer can be dissolved in water. A dilute solution again contains only monomeric units. Thus, germanium does not seem a good choice for replacing silicon in silicones.

Until a few months ago, silicone-analogous polymers of tin have been described as being amorphous, insoluble and infusible materials. In a recent publication, Reichle[17] reported on the preparation and properties of some "stannoxanes." Dimethylstannoxane was found to melt, with decomposition, between 700 and 750F., while di-n-octylstannoxane melted at about 550F. to a clear liquid, decomposing above this temperature. The latter polymer was the only one soluble in organic solvents, giving an average molecular weight of 8,900 ± 10%.

Not the Same as Silicones

Most of these polymers, analogous in structure, are quite different from silicones. They do not form rubbers or gums of low softening point and high solubility in organic solvents. Instead, they form hard, crystalline, high-melting and brittle solids. This difference has been explained in terms of the more-ionic tin-oxygen bond, which could lead to a crystalline three-dimensional R_2Sn^{+2}-O^{-2} lattice.

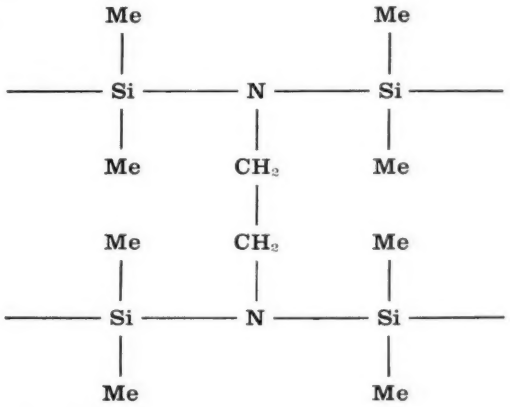
Very little is known about the corresponding lead compounds, the plumboxanes, that probably also exist in polymeric forms.

Other Variations

Variations of silicone polymers considered so far were arrived at by replacing part or all of the silicon in the repeating (R_2Si0)- unit by other elements. In other words, we discussed only siloxane, metallosiloxane and metalloxane polymers, all containing oxygen atoms in their backbones.

Replacement of oxygen with nitrogen in a siloxane leads to the so-called silazanes, which have polymeric -Si-NH- chains. They have been studied in some detail and are sensitive to water—decomposing with ammonia liberation into polysiloxanes. Silazanes have not found commercial applications at the present time.

An interesting silazane polymer was reported a few months ago.[18] Coordination of its double-chain structure, shown below, with copper or beryllium eventually leads to solid, resinous materials that have improved stability toward water.



Aminoborine and phosphinoborine polymers, discovered within the last ten years, can be considered formally analogous to hydrocarbons, if we consider that carbon-carbon bonds are replaced by nitrogen-boron or phosphorus-boron bonds. For example, $(H_2NBH_2)_n$ is formally analogous to polyethylene, although there are important differences in the nature of the bonds.

The properties of phosphinoborines are quite interesting. Burg and Wagner,[19] for the first time in 1953, pyrolyzed dimethylphosphine borine and obtained cyclic trimers and tetramers, according to the equation:

$$n\,(CH_3)_2PHBH_3 \xrightarrow{\sim 350\ F.} nH_2 + [(CH_3)_2PBH_2]_n,$$

where n = 3 and 4

The trimer is very stable to heat, decomposing only slowly at 750F. Chemically it is unreactive—heating with concentrated hydrochloric acid to 550F. is required to hydrolyze it.

Small amounts of an apparently higher polymer, which in 1953 was not characterized, were also formed. Since then, Wagner and Caserio[20] have reported preparation, in substantial yields, of two presumably linear phosphinoborine polymers, $(R_2PBH_2)_n$, where R is CH_3 or C_2H_5. Molecular weights of 1,800 and 6,000 were measured on polymers that melt at 240 and 340F.

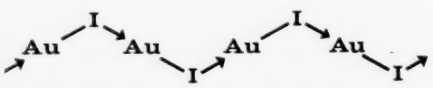
What Are Coordination Polymers?

A considerable effort in the search for inorganic polymers concerns itself with coordination polymers.

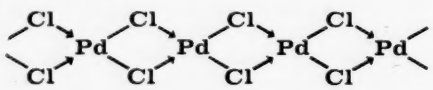
But let's define the term "coordination." Formation of coordinate bonds is unique in inorganic chemistry. Bond formation depends upon the ability of certain metals to surround themselves with more atoms or groups than one would expect from the usual

valence. Gold iodide, for example, has the formula AuI. Based on this formula, we would conclude that only one iodine is bonded to each gold atom by a chemical bond—but gold likes to be surrounded by two partners. To satisfy its coordination number of two, a second iodine "coordinates" to each gold, forming a coordinate bond.

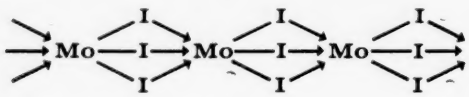
The resulting structure[21] is shown below. Coordinate bonds are indicated by arrows. Zigzag chains in this compound are similar to chains found in organic polymers.



This is a simple example. Other metals have coordination numbers of four or six, and consequently more-involved geometrical patterns are possible and known to exist. An example of the former is palladium. Palladium dichloride consists of parallel chains[22] that contain double bridges of chlorine. One of these chains is shown below.



Molybdenum iodide contains triply bridged molybdenum of coordination number six (see below). Molybdenum bromide has an analgous structure.[23]



Nothing is known about the mechanical properties of these compositions.

For Future Research

Answers to important basic questions are badly needed on inorganic polymers. For example, on coordination polymers:

Do chains in coordination compounds correspond to chains in organic polymers?

Do such compounds exhibit typical polymer properties? If not, is it the nature or strength of the forces in and between the chains that makes an important difference?

How much weaker must forces between the chains be than those holding backbone elements together to allow thermal separation of the chains without destroying the backbone?

What is the meaning of "molecular weight" in infinite-chain coordination polymers?

It will take time to find the answers. In the meantime, research on synthesis of new polymeric systems must continue.

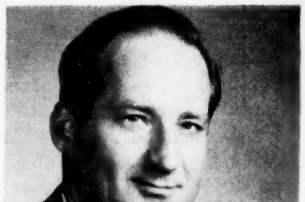
The government plays an important role in supporting inorganic polymer research. The Office of Naval Research, the Air Force and various other government agencies support important programs in this field. Universities, as well as chemical companies such as Pennsalt, U. S. Borax, Monsanto, American Potash and others, have investigations under way. Although no one yet has reported preparation of an inorganic polymer that is elastomeric (or even flexible) and able to withstand temperatures above 1,000F., the search continues.

Certainly the reward for success will be great. More and more new materials will be made and evaluated. Some of these products, in addition to heat stability, will probably have other interesting properties (optical, electric, magnetic) that will open up new uses; some not even dreamed about today.

References

1. Strong, J. D., *Jour. Phys. Chem.*, **32**, 1,225 (1928).
2. Meyer, K. H., Go., Y., *Helv. Chim. Acta*, **17**, 1,081 (1934).
3. Sakurada, K., Erbring, H., *Kolloid-Z*, **72**, 127 (1935).
4a. Specker, H., *Z. Anorg. Chem.*, **261**, 116 (1950).
4b. Specker, H., *Angew. Chem.*, **65**, 300 (1953).
5. Meyer, K. H., Sievers, J. F., *Naturwiss.*, **25**, 171 (1937).
6. Jenckel, E., *Kolloid-Z*, **84**, 266 (1938).
7. Liebig, J., Wohler, A., *Ann. Chem. Liebigs*, **11**, 9 (1934).
8. de Ficquelmont, A. M., *Compt. Rend.*, **202**, 423 (1936).
9. Patat, F., Derst, P., *Angew. Chem.*, **71**, No. 3, 105 (1959).
10. Meyer, K. H., others, *Helv. Chim. Acta*. **19**, 930 (1936).
11. Kuhn, W., *Kolloid-Z.*, **76**, 258 (1936).
12. Specker, H., *Angew. Chem.* **65**, No. 11, 299 (1953).
13. Andrianov, K. A., others, *Doklady Akad. Nauk S.S.S.R.*, **112**, 1,050 (1957); ibid., 114, 1,005 (1957); *Izvest. Akad. Nauk S.S.S.R.*, 1956, 74.
14. Hornbaker, E. D., Conrad, F., *Jour. Org. Chem.*, 24, 1,858 (1959).
15. Brown, J. F., others, *Jour. Amer. Chem. Soc.*, **82**, No. 23, 6,194 (1960).
16. Brown, M. P., Rochow, E. G., *Jour. Amer. Chem. Soc.*, **82**, 4,166 (1960).
17. Reichle, W. T., *Jour. Polymer Sci.*, **49**, 521 (1961).
18. Minne, R., Rochow, E. G., *Jour. Amer. Chem. Soc.*, **82**, 5,625 (1960); **82**, 5,628 (1960).
19. Burg, A. B., Wagner, R. I., *Jour. Amer. Chem. Soc.*, **75**, 3,872 (1953).
20. Wagner, R. I., Caserio, F. F., *Jour. Inorg. Nucl. Chem.*, **11**, 259 (1959).
21. Weiss, A., Weiss, A., *Z. Naturforsch*, **11b**, 604 (1956).
22. Wells, A. F., *Z. Krist*, **100**, 189 (1938).
23. Lewis, J., others, *Chem. & Ind.*, 259 (1960).

Meet the Author



DR. BARTH-WEHRENALP *is director of inorganic research in the research and development dept. of Pennsalt Chemicals Corp., Wynamoor, Pa. He has a Ph.D. (maxima cum laude) from the University of Innsbruck, Austria (1949). He came to the U.S. in 1951, after teaching at Innsbruck, to become assistant professor of physics and chemistry at La Salle College, Philadelphia. In 1953, Dr. Barth-Wehrenalp joined Pennsalt. He has broad experience in inorganic synthesis, but is primarily interested in halogen chemistry, inorganic polymers and high-energy chemicals.*

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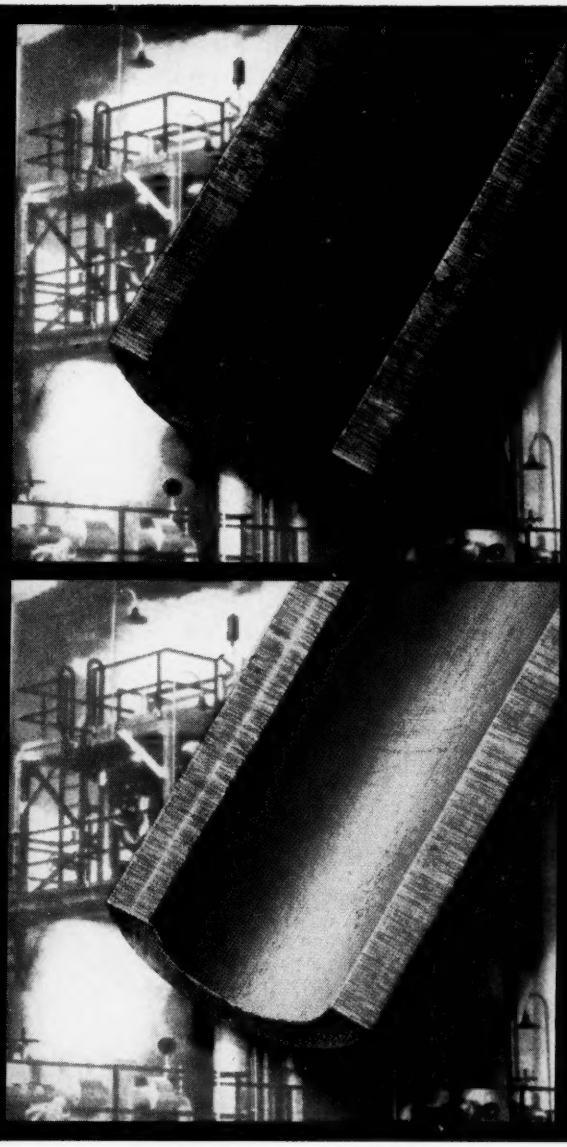

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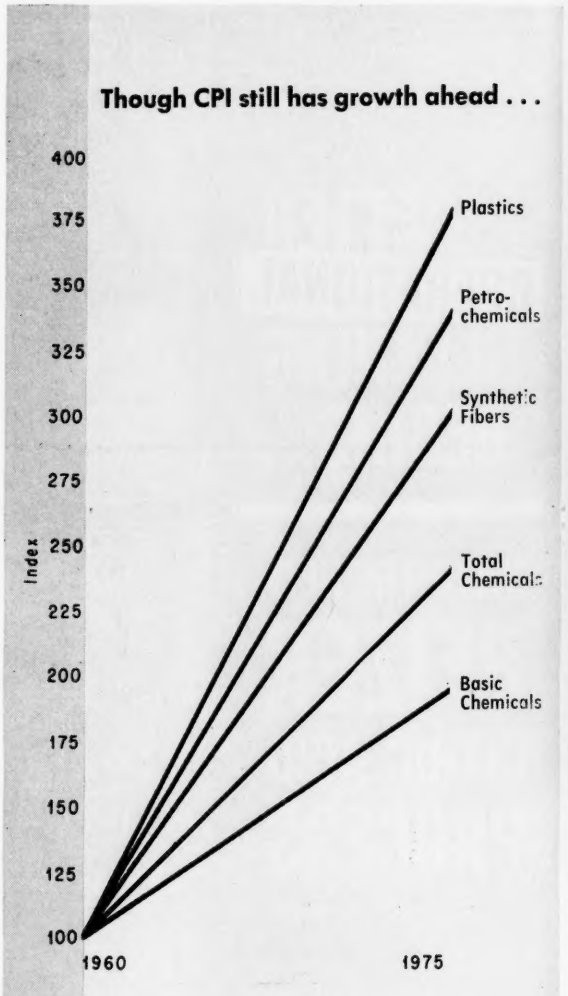

. . . does chemical engineering?

ChE degrees, % of all engineering degrees

Academic year	Bachelor	Master	Doctor
1949–50	9.2%	14.6%	36.2%
1950–51	9.5	14.5	29.7
1951–52	10.1	13.1	27.1
1952–53	10.1	11.6	24.8
1953–54	10.1	10.8	22.5
1954–55	9.7	10.6	23.2
1955–56	10.1	11.6	22.3
1956–57	9.8	11.6	24.5
1957–58	9.4	9.8	19.6
1958–59	8.9	8.9	20.0
1959–60	8.6	8.8	21.6
1960–61*	8.0	8.3	20.0

*CE estimate

When you couple projected demand for engineering services with trends in enrollments and degrees, there seems to be a case for viewing with alarm.

Readers of these columns over the years have been confronted with a seemingly massive array of statistics that purports to tell the supply-demand story. This includes enrollment and degree data from the Federal Government, demand studies from Engineering Manpower Commission, national salary surveys, and long-term trend information.

In the last category is a study now being made by National Science Foundation. Not yet released, "Long-Range Demand for Scientific and Technical Personnel" attempts to project data collected by the Bureau of Labor Statistics, and come up with meaningful figures on requirements of the economy in 1970 for scientists and engineers.

Unfortunately, the study does not make its extrapolations by engineering branch, even though many of such data were collected. Instead, it treats engineers as a whole, then considers employment within industry, government and educational institutions. So while

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it may, hopes NSF, draw attention to problems of supply and demand in engineering services, there still will not be a clear picture of what's happening to chemical engineering.

What the NSF Report Shows

In 1970, the new study shows, the U. S. industrial economy will require nearly twice as many scientists and engineers as were employed in 1959.* The demand for engineers alone will increase by as much as 50%. And in mathematics, the 1970 requirement predicted ranges from two to three times the 1959 level.

As it has studied the draft of its report over these past six months, NSF has had to modify some of its initial reactions to the figures. For example, when McGraw-Hill's Washington Bureau checked this spring, NSF said that college enrollments must be stepped up now if a manpower shortage is to be prevented at the turn of the decade.

Now, that statement is qualified by the Foundation. Based on school output, there is no question but that supply will fall short of demand. There is, however, a large input of engineers that doesn't come from the colleges. In 1959, this amounted to nearly 25% of the total. So the supply picture remains fuzzy, and this may be one reason why NSF hesitates to make recommendations about possible courses of action.

Other reasons, too, argue against too-definite conclusions from the long-range-demand study. Data for the base year, 1959, were collected at a time that the industrial outlook was pessimistic. When gross national product is slowed, predictions tend to be on the low side; an upturn in the economy, however, tends to make the predictors bullish.

Another factor is that the report will be rather stale by the time it is made public. One effect of this can be seen by considering the time lag between when freshmen enroll and when engineers enter the profession. The new advanced-degree engineers and scientists of 1970—particularly at doctorate level—are probably already enrolled in their freshman year. (Another thing: report does not break down its figures by degree level.)

Some checkpoints were used, however, to keep the information from wandering too far. To check its extrapolations, Bureau of Labor Statistics made a special survey of a large number of firms in both the chemical and the electrical equipment industries. The original projection for the chemical industry was found to be fairly accurate when compared with the special study, but the original electrical equipment projection had to be revised.

Some Other Dangers of the Study

In an official study of long-range demand, such as this one undertaken by NSF, you can't expect that there would be any intuitive tempering of the results. But engineering demand studies should, in some observers' views, be tempered by those who use them to plan the effects of manpower changes. Among those who need a large pinch of salt: educators, recruiters, career-planning high school students, career counselors, technical societies.

Take what's been happening to the practice of engineering. At least four factors have a dynamic effect on manpower requirements that isn't reflected in the simple static extrapolations.

- Fewer engineers are needed for the purely calculational aspects of engineering projects. This was brought out vividly last spring by Dr. Thomas Stelson of Carnegie Tech (*Chem. Eng.*, May 29, p. 102) when he claimed that engineers shouldn't attempt to compete with computers on the computers' terms. For chemical engineers, the handwriting may be on the wall with last winter's announcement of Shell Development's CHEOPS computer-design optimization program (*Chem. Eng.*, Mar. 20, p. 80).
- Certain basic parts of the chemical industry have so well-known a technology that few design changes are made from year to year. Those changes that are made are of a process-improvement nature, rather than a fundamental nature. This means that new plants don't require much new "engineering" in these parts of the industry.
- Another effect of a maturing industry is the increasing storehouse of "packaged" plants. At the same time, the handbook knowledge of the profession, as well as of individual firms, increases daily. This recorded information means that less new ways to do things have to be discovered each time a new plant is designed and built.
- Industrial maturity adds another factor, too. The pace of innovation slackens as the industry grows older and as emphasis changes from the technological to the financial and marketing aspects.

Effects of Dynamics on the Predictions

It's possible, of course, that in some way not well-understood these dynamic effects are felt in engineering enrollments. If so, there are two lessons that might be drawn.

First, perhaps educators, technical groups and government planning groups shouldn't worry so much about the drop in enrollments in the engineering schools. Particularly insidious here is the inevitable comparison of U. S. and Russian statistics. Remember that the Soviets are at a different stage of economic growth than we.

Second, it might be economically dangerous to embark on programs to artificially stimulate enrollment, such as by laws similar to the National Defense Education Act, because it may depress salaries, throw engineers out of work, in the long run.

Though the National Science Foundation plans to publish its study without recommendations, such recommendations will, of course, come from other groups and persons. Just keep that salt shaker handy!

* The base year for the study is 1959. To arrive at projected estimates, Bureau of Labor Statistics took employment trends over a 5 or 6 year period, coupled this with gross national product, predicted both, with some adjustment, to 1970. A report of the base-year study was made in these pages (*Chem. Eng.*, Jan. 23, p. 154).

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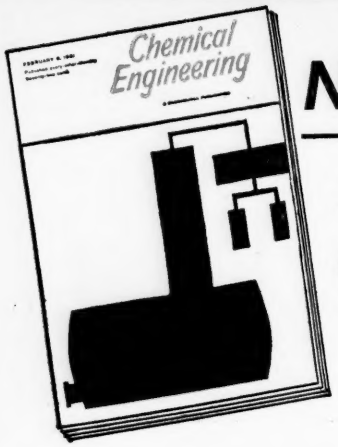

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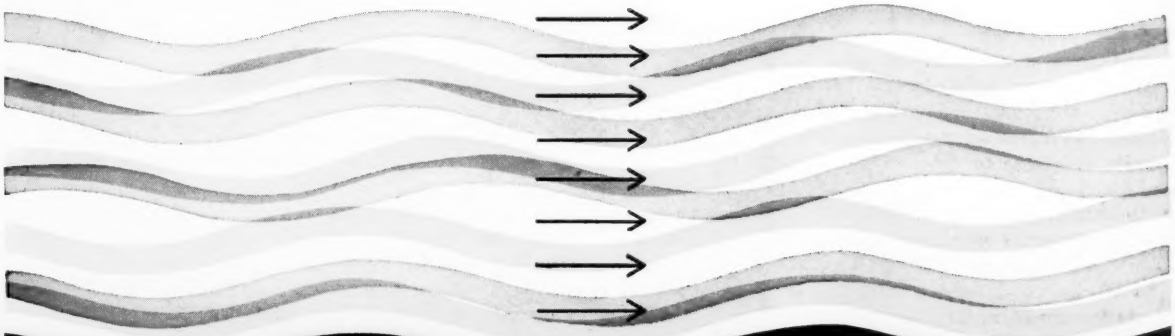

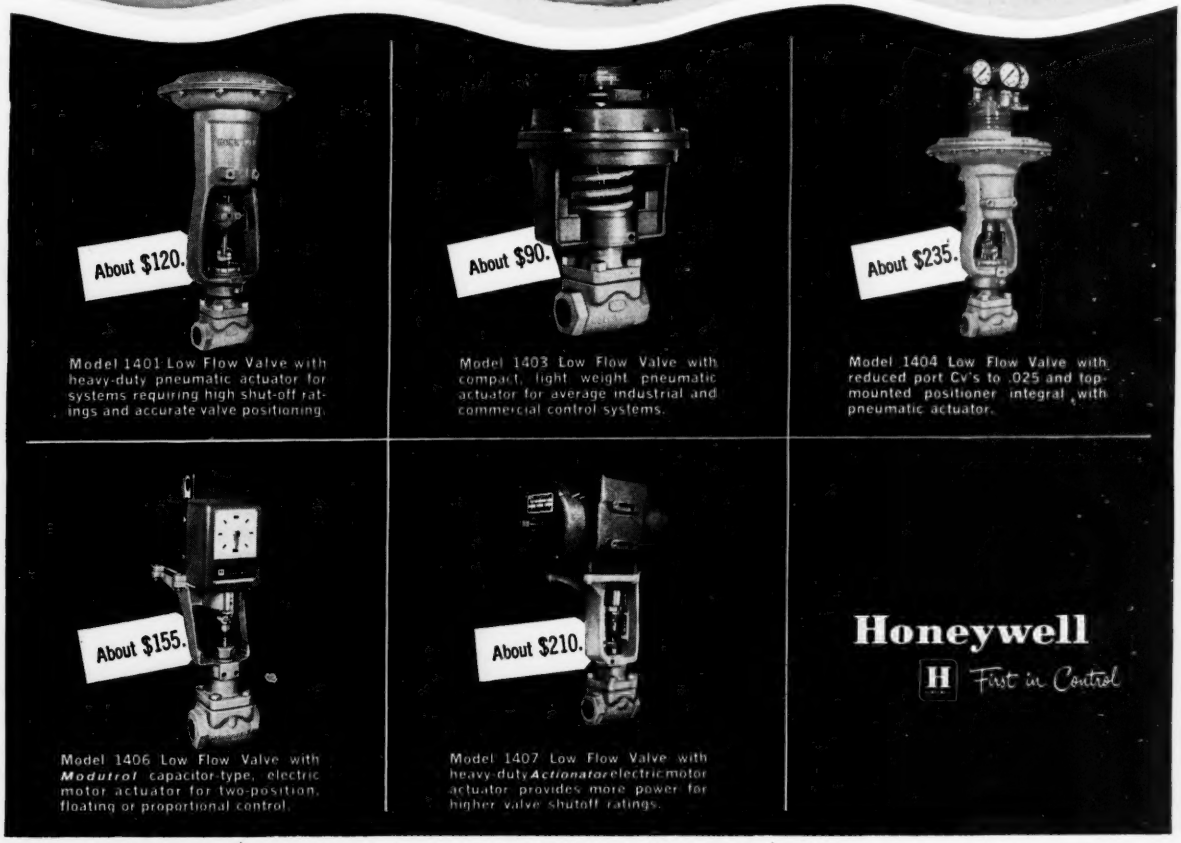

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NEWS BEHIND THE NEWS: EX-CE EDITOR IN BERLIN

One chemical engineer's job has carried him into the jaws of communist tyranny. He is Pete Forbath, a former CHEMICAL ENGINEERING ***editor, now chief of McGraw-Hill's Bonn news bureau. What follows is part of his background account of events during the August pressure buildup on West Berlin.***

I flew up to Berlin a few days after the communists had brought the Iron Curtain clanging down on the East-West sector border.

The mood in the city was explosive. I was in Willy Brandt's office in the Schoeneberger Rathaus—along with Kurt Lachmann of *U.S. News & World Report*, Max Ascoli and George Baily of *The Reporter*—when the communists issued their newest demands, cutting the number of crossover points and threatening Western air rights.

We had an interview with Brandt scheduled. But it was scrapped, and he headed across town to a meeting of the Allied Komendaturn, followed by an emergency session of the West Berlin cabinet. Within a matter of hours, Allied response was visible in the streets. By six o'clock, two American tanks had taken up positions within 50 yards of the sector border, and a couple of infantry squads were deployed along the border.

One Small Tragedy of Hundreds

At Moritzplatz—one of four crossover points for West Berliners—a young East Berlin woman had come right up to the concrete-and-brick wall that divides East and West. With her stood a Vopo (People's Police) officer, and surrounding them were four armed Vopos. West Berliners, on their side of the then-chest-high wall, were talking to her.

My photographer and I walked over to see what was going on. Her two children, it seems, had been visiting her parents in West Berlin when the city was sealed off. Now she had received permission to meet her parents and take the children back. The parents were late, however, and the Vopos were impatient.

We suggested that she give us the address of her parents, and then dispatched a boy on a motor scooter to find out what was keeping them. The boy returned with her father but no children. The old man, close to tears, confused, waved his arms helplessly. Like many others, the family had planned to escape to West Berlin. The children had been sent to visit their grandparents during the summer holiday; the mother was going to use a trip to West Berlin to bring them back as a pretense to flee herself.

The border sealing shattered the plan. Now the young woman couldn't leave East Berlin. After a brief whispered conference with his daughter over the wall, the father walked back to us. As he passed, he said, "I'm not bringing the children." He didn't come back, either. The young woman continued waiting by the wall for another half-hour. Then the Vopos moved her back about 100 yards where she waited for some time longer. Finally, they lost patience and took her away.

A Sudden Failure of the Tongue

Nearly everybody covering the Berlin story had urged me to take a look at the sealed border before starting interviews. It would make everything else I'd hear more meaningful, they said. So when I first got to the city and had three hours to kill before an appointment, I dutifully strolled down to the Brandenburg Gate.

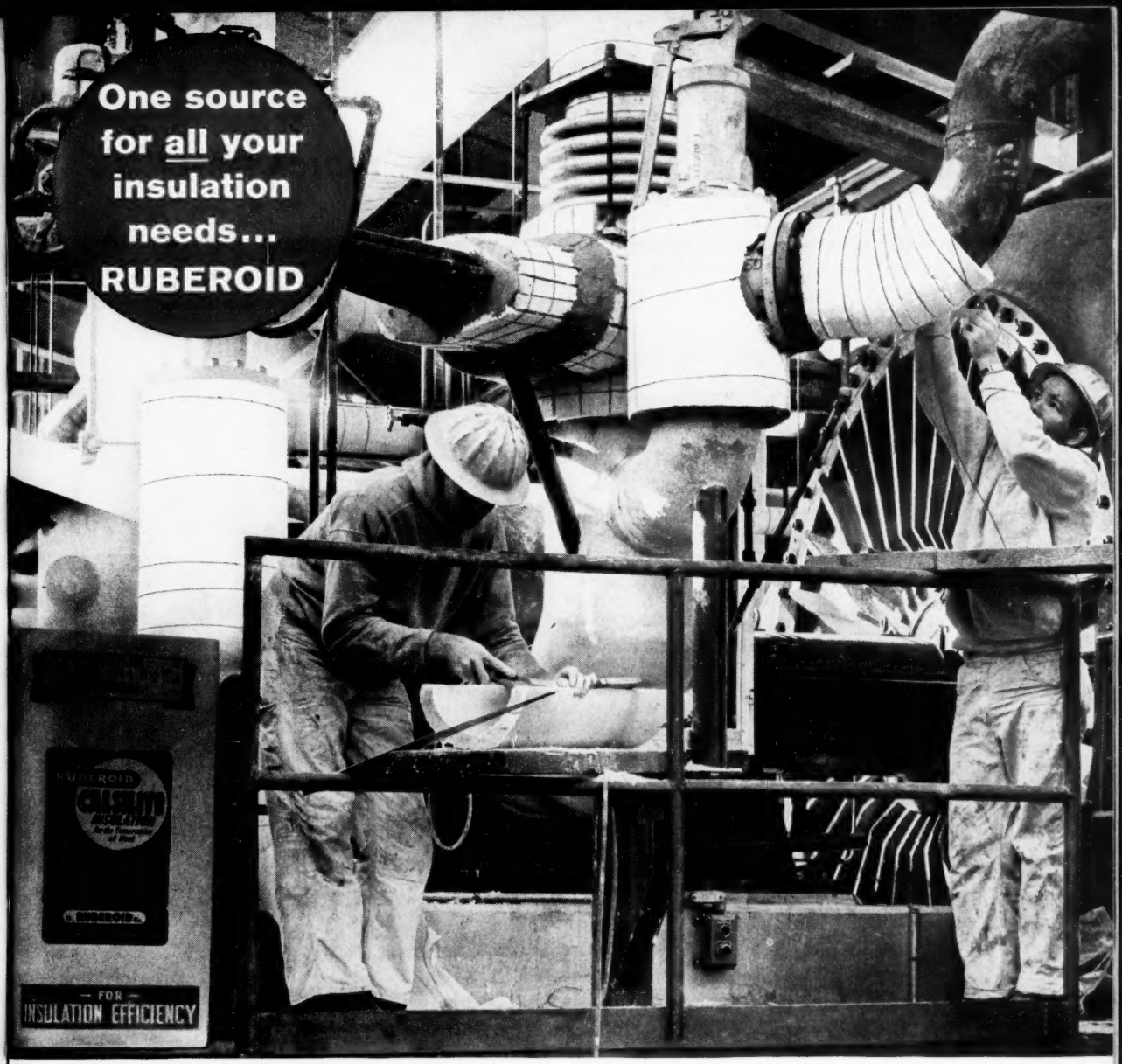
I thought at the time that perhaps the Brandenburg Gate was one of the less-dramatic border points and decided to walk along the border in search of something more exciting. As I walked, I gradually headed toward the concrete wall that the communists were erecting along the Wilhelmstrasse, passed the Reichstag building.

No one stopped me. I thought it strange that there was no one around, but put it down to the early hour. While I was strolling along, five Vopos paralleled my walk on the other side of the concrete wall. The Wilhelmstrasse dead-ends in a river, and there the Vopos began talking to me, invited me to come across. I declined and began to retrace my steps. Suddenly, two of the Vopos vaulted the wall and grabbed me. It was only then that I discovered that they had built their wall a good ten yards inside the East sector.

The Vopos marched me back to the police station at the Brandenburg Gate, one still holding my neck and jacket, two others with rifles at the ready behind us. In two hours of detention in the police station, my passport and press credentials were checked against a complicated listing of names and numbers. But when one officer, who was convinced he'd find my name there, failed to connect me and the list, he tried a new tack.

Peering at my passport, he asked if I were an American, I said yes. A born American? Again, I said, yes. Are you sure? Yes, I was sure. Then where did you learn to speak German? I told him in school. From that point on, I developed great difficulty in pronunciation and sentence structure. It seemed wiser.

Finally a Vopo officer came in and told me I could go. When I got out into the street again, the communists were playing a lively marching tune over a battery of loudspeakers. A choral group joined in with lyrics about the happy life that people lead in the German Democratic Republic.



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SIMPLE DEVICE FOR CONTINUOUS CO INDICATION

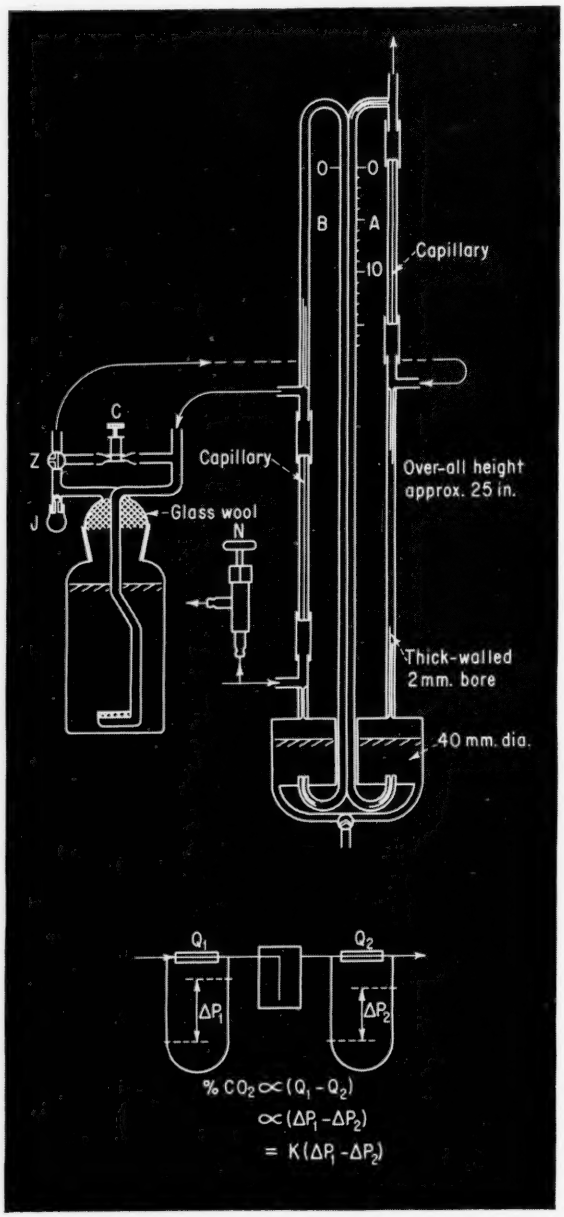
Two manometers, in series, and an absorption chamber give a continuous analysis of synthesis or product gases.

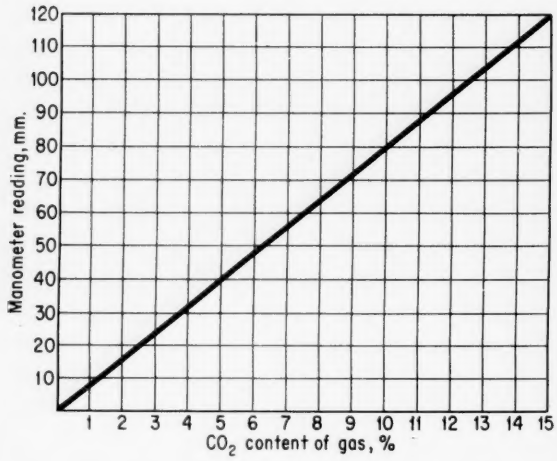
Winner of the August Contest*
W. H. GRIES, *Sasolburg, Orange Free State, South Africa*

The sketch shows a simple, reliable and inexpensive device for continuous CO_2 determination. We developed the apparatus for services on our synthesis and product gases after our automatic CO_2 recorder proved to be unreliable.

The device operates by comparing the flow rates of the gas before and after absorption of the CO_2. The comparison is accomplished by two manometers in series, with an absorption chamber in between them.

Length and bore of the capillaries were selected to give a pressure drop of approximately 20 in. of water at a flow rate of 150 ml./min. This flow is maintained





COMING NOVEMBER 27

Automatic Gas Sampling System

George F. Shea, September Contest Winner

***How Readers Can Win**

$50 Prize for a Good Idea—Until further notice, the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for publication in the Plant Notebook. Each period's winner will be announced in the second following issue and published in the fourth following.

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Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant Notebook Editor, *Chemical Engineering*, 330 W. 42 St., New York 36.

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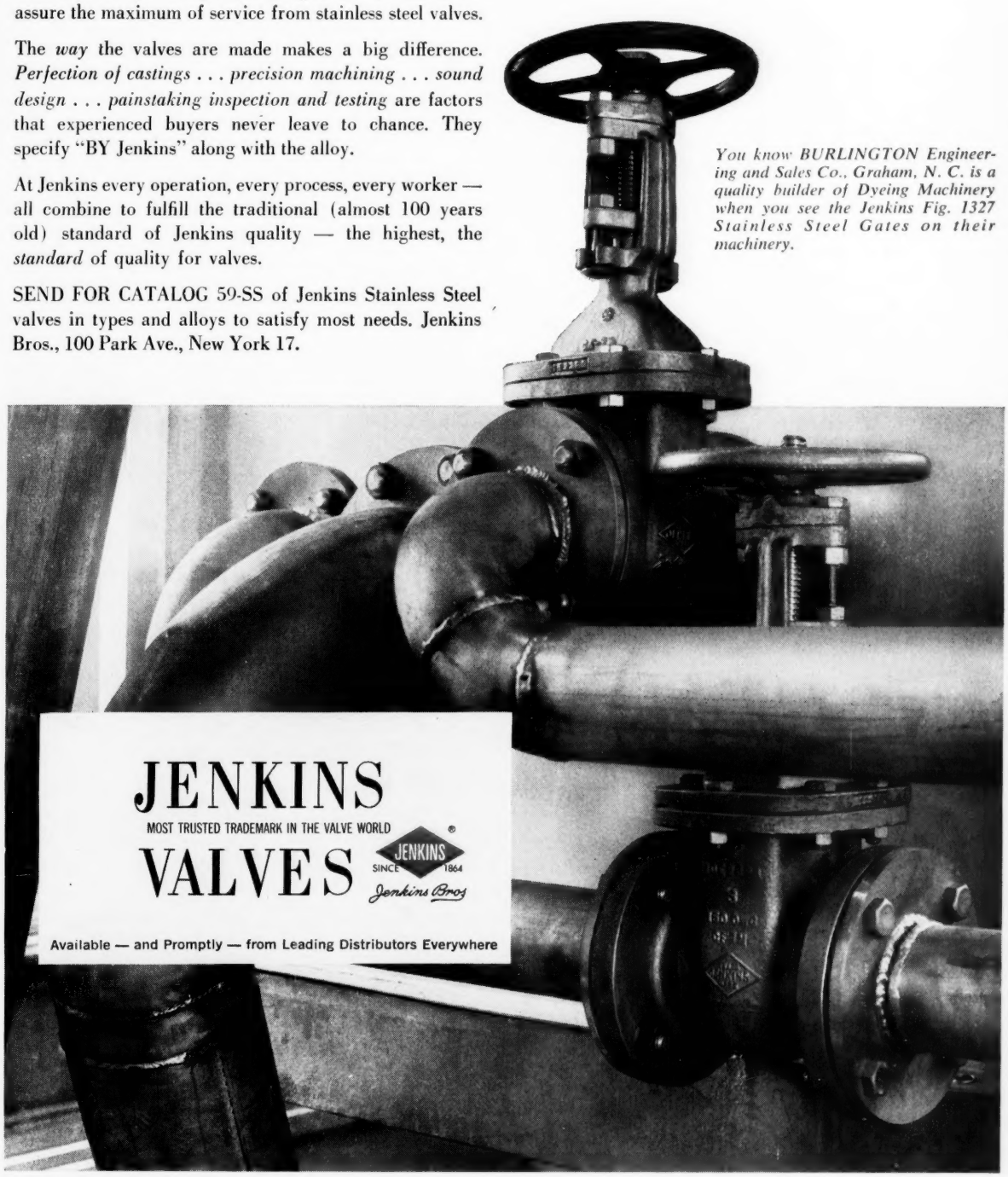

You know BURLINGTON Engineering and Sales Co., Graham, N. C. is a quality builder of Dyeing Machinery when you see the Jenkins Fig. 1327 Stainless Steel Gates on their machinery.

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VALVES

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by a needle valve N, which regulates the discharge of any excess flow and serves to purge the supply line.

The meniscus of the manometer liquid (water and dye) in leg B is set to an arbitrarily chosen zero point by adjusting N, and the meniscus in leg A settles automatically to the correct figure on a % CO_2 scale. The gas volume between the two capillaries should be as small as possible to minimize response time.

The equivalence of the two capillaries can be checked either by running the device on an inert gas, such as nitrogen, or by bypassing the absorption chamber with valve Z. This valve can also be used for discontinuous operation or for quick checks on the equivalence of the capillaries. Clamp C serves to create a resistance equal to that of the absorption chamber.

After the zero point has been chosen, one more point is required for calibration, since the calibration curve is a straight line. This point can be found by doing a simultaneous Orsat analysis while the device is in operation. For different gases, additional calibrations must be made.

During operation, methyl red indicator at I warns the operator of any CO_2 escape.

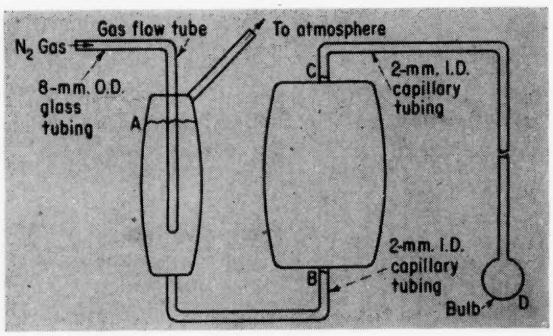
The author wishes to thank the South African Coal, Oil and Gas Corp., Ltd., for approving without reservation the publication of this article.

AUTOMATIC DEVICE MAINTAINS LIQUID NITROGEN LEVEL

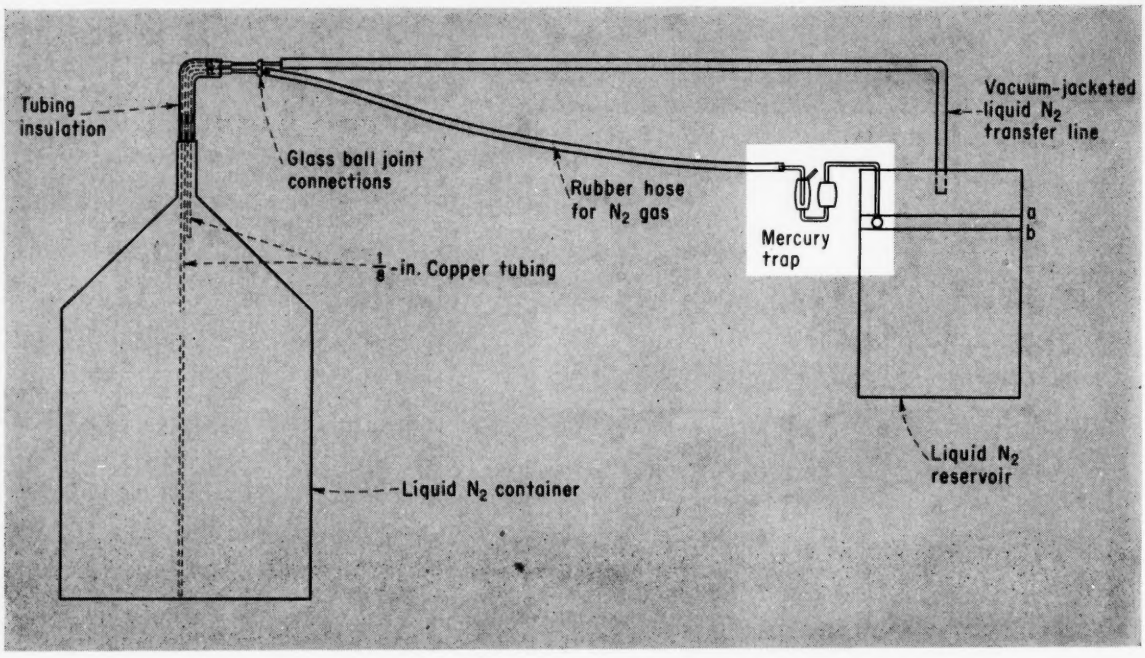
BERNARD D. FULKS
West Virginia Institute of Technology

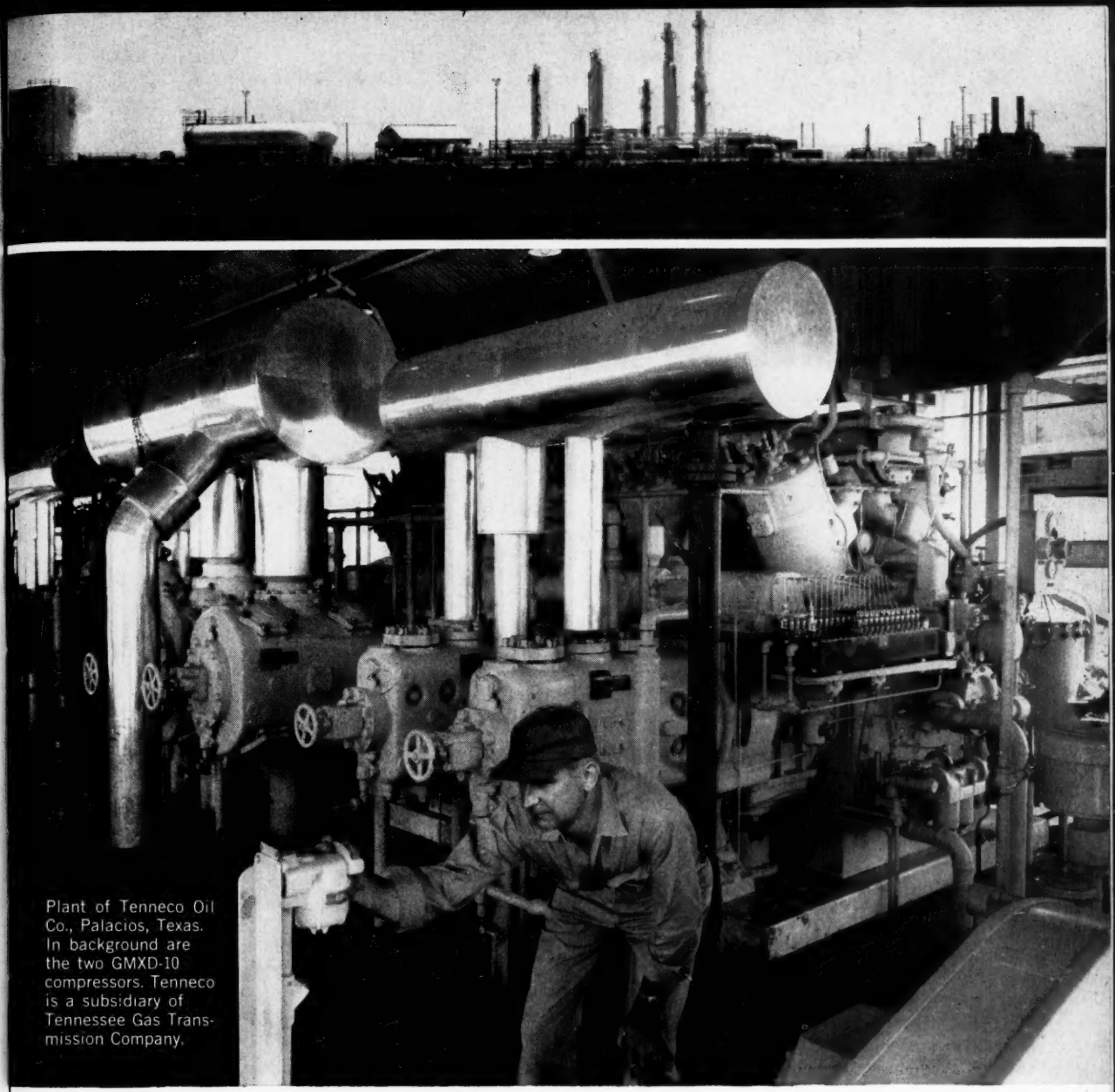
Liquid nitrogen cold traps are frequently used to collect minute quantities of condensables being pumped from high-vacuum systems (10^{-6} mm. Hg). For efficient operation, the trap must be immersed in a constant volume of liquid nitrogen. A low liquid nitrogen level results in a loss of "trapped" substances, while an excess will evaporate quickly and result in useless consumption of liquid nitrogen.

Maintaining a constant liquid nitrogen level in an insulated cold trap is a difficult task to perform manually. The transfer of nitrogen to the trap reservoir by hand also results in expensive spillage and evaporation losses. And, if the system is kept under vacuum



Glass mercury trap controls nitrogen vent gas, see below.





Plant of Tenneco Oil Co., Palacios, Texas. In background are the two GMXD-10 compressors. Tenneco is a subsidiary of Tennessee Gas Transmission Company.

Compressors handle heavy load in low-temperature processing

Compression facilities of the new Tenneco Oil Company plant at Palacios, Texas, were designed for 55 mmcfd. Its two Cooper-Bessemer compressors are now handling 70 mmcfd, 'round the clock.

This low-temperature oil-absorption processing plant went on stream January, 1961, and soon reached, then surpassed its rated capacity. It will soon be expanded to 90 mmcfd.

Its two 660 hp Cooper-Bessemer GMXD-10 compressors, shown above, are giving exceptional service under these severe conditions. Each unit has two stages in refrigeration for processing and two stages in booster service for returning gas to supply lines.

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continually, an attendant must stay over the weekend.

The apparatus shown in the illustrations overcomes this problem by transferring liquid nitrogen to the trap automatically. The nitrogen level in the trap thereby stays within the desired limits without constant observation and adjustment.

Although liquid nitrogen is stored in insulated containers, a heat loss from the surroundings to the nitrogen causes constant evaporation. A vent is provided on the container for the release of the nitrogen gas. If this vent is closed, the resulting pressure can be used to force the liquid over into the reservoir. The mercury trap described here does this automatically.

The length of the gas finger on the glass trap depends upon the size of the insulated reservoir and the volume of liquid nitrogen needed. Mercury is poured into the trap, where it traps air between points *B* and *D*. This air holds the mercury between points *A* and *B*. In this position, the mercury will cut off the nitrogen gas through the flow tube to atmosphere.

If the bulb is immersed in liquid nitrogen, the trapped air will contract, and atmospheric pressure will force the mercury into reservoir *BC*, permitting nitrogen gas to flow through the trap to atmosphere. But, when bulb *D* is warmed, the mercury will be forced back to its original position by the expanding air, thereby completing one cycle.

The equipment is arranged as shown, with the trap in the reservoir. When the liquid level is at point *b*, the mercury cuts off the flow of nitrogen vent gas and the resulting pressure in the storage container forces liquid up through the copper tubing and into the liquid nitrogen reservoir. Flow continues until the level is at point *a*, at which time the mercury in the trap recedes, releasing the pressure and stopping the liquid nitrogen flow.

The liquid-nitrogen storage container is connected to the system by means of a two-hole rubber stopper fitted into a short length of ½-in. vacuum hose. The other end of the hose fits over the neck of the container. The stopper holds two ⅜-in. copper tubes, one of which reaches the bottom of the container for liquid delivery. The other is a short piece for release of vent gas. External hose and tubing is insulated with rubber electrical tape, and the connecting glass tubing is vacuum jacketed.

Although the mercury trap was designed to transfer liquid nitrogen at required intervals, its use is not limited to this application.

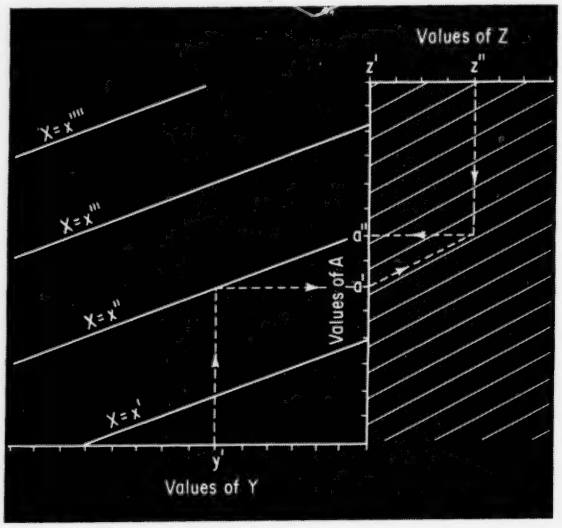
Test Your CEQ

ROBERT LEMLICH

The pressure-temperature relation for an ideal gas undergoing a reversible adiabatic compression or expansion is given by the familiar equation

$$(T_2/T_1)^{\gamma/(\gamma-1)} = P_2/P_1$$

where γ is c_p/c_v. How should this relationship be modified if each pound of gas contains M lb. of dust of constant heat capacity c_d, which is always in thermal equilibrium with the gas? *Answer on page 138*



GRAPHICAL METHOD FOR SHOWING FOUR VARIABLES

W. A. MASON, *Stockton-on-Tees, England*

There is a useful and compact, though relatively unknown, method of showing graphically the relationship of four variables. It incorporates what is essentially a sliding abscissa scale. For example, if the relationship of the variables is expressed in the form $A = X + Y + Z$, then the graphical solution is as shown.

For clarity in the illustration, the Y and Z scales are shown on opposite sides of the A scale. In practice, for compactness, both scales would be drawn on the same side. The diagram is constructed in the following steps:

1. Plot values of A vs. Y for various values of X, using a constant value of Z, say z'.
2. Draw a series of lines with a slope chosen so that the change in value from z' to z'' will be equivalent to the change from a' to a''.
3. To solve for A when the other three values are known, follow the chain lines as shown.

This method can also be applied to nonlinear scales. The relationship $A = XYZ$, for example, could be represented by the same diagram as above if the scales were logarithmic. Similarly, combinations of multiplication and addition can be dealt with by proper choice of scales.

Fourteen years ago Morton Salt stopped worrying about hydraulic oil performance

Harlen Bufka, assistant mill foreman (center) and American Oil's Norm Pagels, review specifications of AMERICAN Industrial Oil. Oil has been used for 14 years in hydraulic press that forms salt blocks under 800-850 tons pressure.

by N. M. PAGELS
About the Author

For 17 years "Norm" Pagels has been providing industrial customers with technical assistance on lubrication problems. His qualifications for this assignment include a degree in chemistry from the Central Michigan University and the completion of his company's Sales Engineering School.

☆ ☆ ☆

Back in 1946, Morton Salt Company installed a 1,000 ton press for forming salt blocks in their Manistee, Michigan, plant. They ran the press briefly with a break-in oil as the hydraulic medium. In 1947, they added our industrial oil to the reservoir. Worries stopped then.

There has never been a complete oil change. Only make-up oil has been added to the reservoir since the initial fill. There has never been any hydraulic pump trouble or a failure of any kind due to the oil. Annually, we take a sample of the oil for analysis by our Technical Service laboratory (at our expense). The oil continues in excellent condition. Morton Salt plant management reports that it (1) holds viscosity (2) resists oxidation (3) lubricates effectively, minimizing wear (4) exhibits excellent demulsibility and (5) is notably resistant to foaming.

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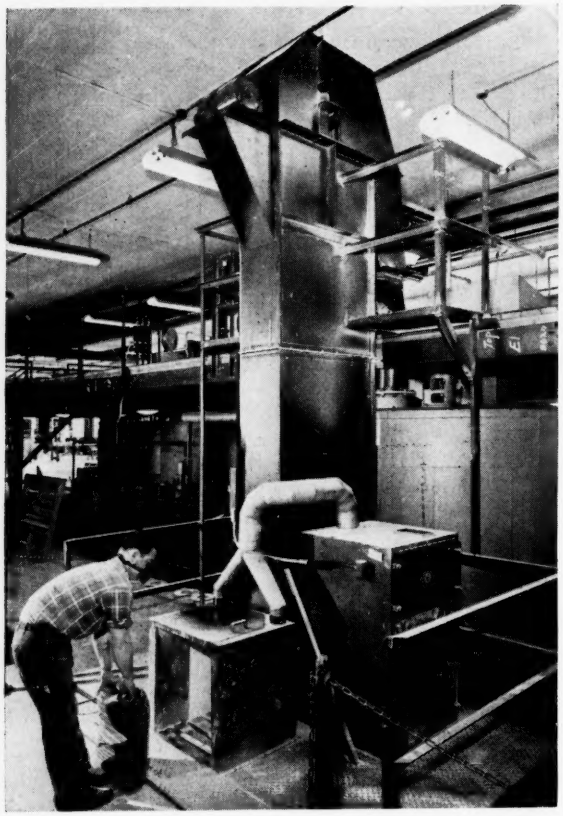


ELEVATOR MOVES ON TRACK TO CHARGE THREE REACTORS

One centrifugal-discharge elevator does the work of three at Amchem Products Inc.'s St. Joseph, Mo., plant. The elevator is mounted on a track, along which it travels to charge reactants to three different reactors that produce agricultural chemicals.

On the same movable platform as the bucket elevator is a Torit cabinet cloth-filter dust collector that retains dust from the obnoxious chemicals used in the process. The collector discharges filtered air through a large rubber hose to the ceiling and out of the working area. The company estimates that this collection of dust saves $250 worth of chemicals in a year, as well as helping to maintain good working conditions in the plant.

The elevator and collector are driven along their track by a gear-motor drive with magnetic brake.

At other Amchem plants, it is necessary to lift all the reactant chemicals, about 4,000 lb. per batch, to a charging platform and then move them by hand along the platform for dumping. George A. Russell, Amchem's chief engineer, initiated the new system and had it included in the original design of the St. Josephs plant.

Maintenance of the system is practically nil, according to Russell. The only detail required for the dust collector is daily shaking of the cloth bags to assure top operating efficiency.

The photo shows a workman about to dump a bag of dichlorophenoxyacetic acid into the elevator's boot, which is connected to the dust collector. The platform supporting the equipment moves to the right.

NOMOGRAPH GIVES DENSITY OF MOIST OR DRY AIR

F. CAPLAN
Kaiser Engineers, Oakland, Calif.

If H is the absolute humidity, then the average molecular weight of an air-water vapor mixture is

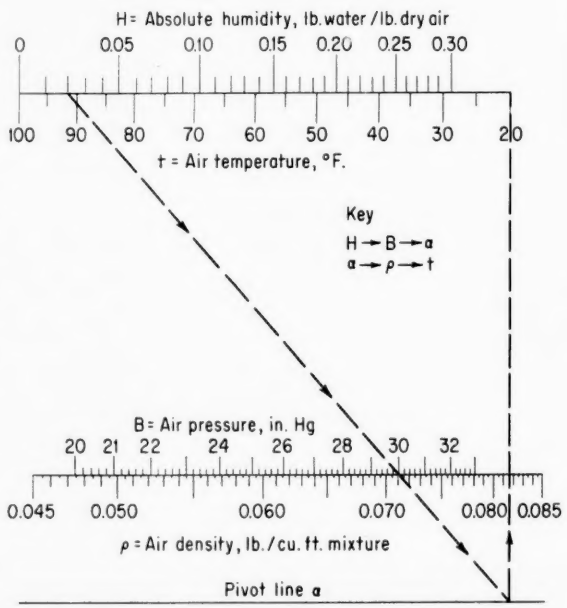
$$M = \frac{W_1 + W_2}{(W_1/M_1) + (W_2/M_2)} = \frac{H + 1}{(H/18) + (1/29)}$$

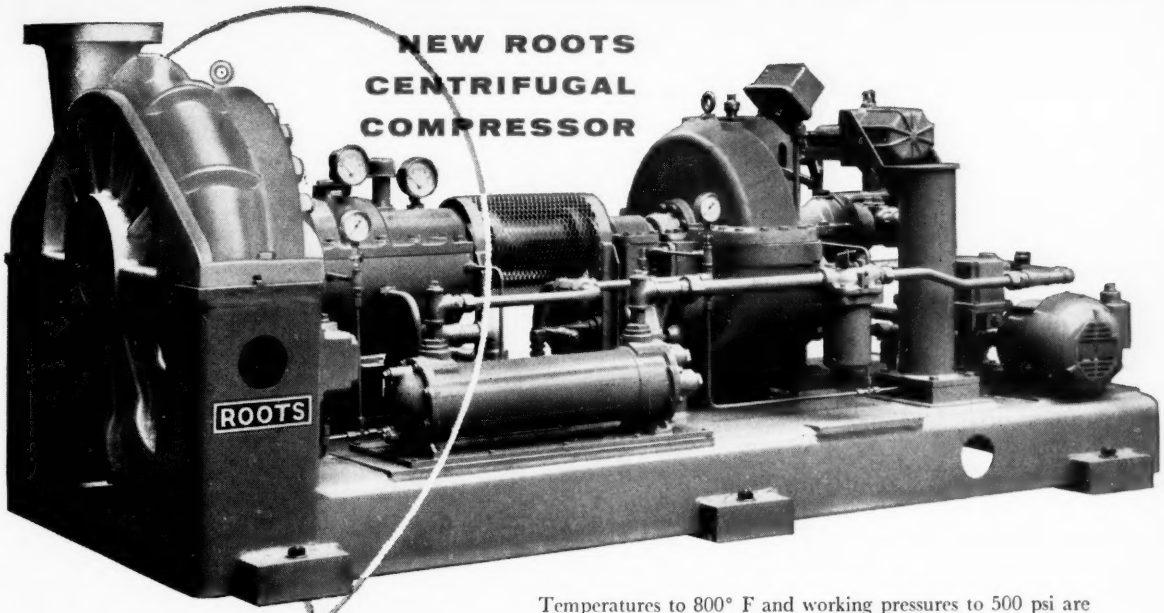
$$= \frac{29(H + 1)}{1.61H + 1}$$

Substituting M in the perfect gas law, we obtain

$$\frac{1.327B(H + 1)}{(t + 460)(1.61H + 1)}$$

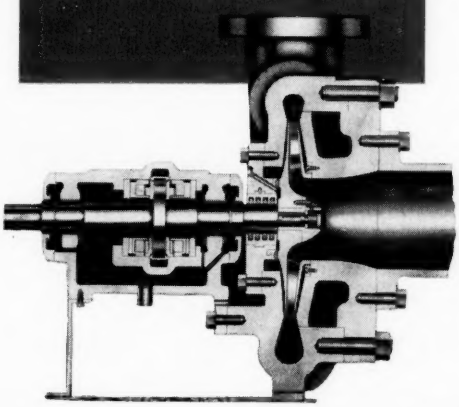
▶ Example—What is the density of air containing 0.020 lb. water per lb. dry air at 29.92 in. Hg and 20 F.? Align $H = 0.020$ with $B = 29.92$ and mark intersection with pivot line a. Align this intersection with $t = 20$ and read $\rho = 0.0815$ lb./cu. ft. of mixture.





TAGGED FOR

HOT GASES AND HIGH PRESSURES



Temperatures to 800° F and working pressures to 500 psi are all in a day's work for the new Roots Model HTP Centrifugal Compressor. With capacities to 5000 cfm, this rugged single stage machine is built to meet the stiff demands of modern refinery, chemical, petrochemical and nuclear plant service. It operates at high speeds, couples directly to a steam turbine or electric motor, can be built in special materials when required, and can be equipped with a wide variety of shaft seals to handle dangerous, dirty or corrosive gases.

A closer look at the cross sectional drawing will show you how efficiency, dependability and long term economy are apparent in this outstanding new Roots design:

- The massive casing is heavily ribbed for strength and rigidity. Centerline support minimizes the effects of radial expansion.
- Collection and diffuser passages are designed for optimum conversion of velocity head to static head.
- Axial inlet assures direct uninterrupted flow to impeller eye.
- Vertical discharge minimizes lateral forces on compressor foundation.
- Forged steel impellers, dynamically and statically balanced, are used for high temperatures or maximum pressure ratings.
- Only one shaft seal is required. All lubricated parts are isolated from the compressor casing.
- Precision machined, forged carbon steel shaft is supported in heavy duty, full pressure lubricated, sleeve bearings.
- Double Kingsbury type bearing absorbs thrust loads in either direction.
- Bearing housing is horizontally split for accessibility. Pedestal is arranged to allow axial movement while maintaining relative alignment of casing, rotor, bearing and seal.

More facts and figures are yours for the asking. Write for new Bulletin SSC-161 today!

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TABLE RECOMMENDS DESIGN VELOCITIES

EDWARD J. GIBBONS
Colgate-Palmolive Co.,
Jersey City, N. J.

This list of recommended design velocities has been taken or calculated from several sources, including manufacturers' literature, handbooks, equipment specifications and technical journals.

Medium	Service	Design Velocity, Ft./Min.	Design ΔP	Remarks
Steam (sat.)	Heating, 0–15 psi.	4,000–6,000		4-in. dia. and over
Steam (sat.)	Process, 500 psi.	6,000–10,000		6-in. dia. and over
Steam (super heat)	Power, +200 psi.	7,000–20,000		6-in. dia. and over
Steam	Miscellaneous	Dia., in., x 1,000	½% per 100 ft.	E.g., 3-in. dia. 3,000 ft./min.
Steam	District heating	50,000–75,000	High	Long lines
Steam	Low pressure		1 oz. per 100 ft.	Heating—max. 4 oz.
Steam	Pump feed lines	800–960		Short, small lines
Nitrogen or air, 2 mm.	Vacuum lines	12,000–15,000	Low, < 0.5 mm.	
Air	Forced air heaters	1,000–1,600		E.g., A.C. reheat
Air	Vent ducts	750–3,000	0.1–1.0 in. WG per 100 ft.	
Air	Furnace supply	1,800–3,500		Forced air supply
Air	Registers	200–500		A.C. grilles
Air	Main ducts	1,500–2,500		Trunk ducts in air-conditioning system
Air	Branch	1,000		
Air	Branch quiet	800		
Air	Washers	500		
Air	Cooling coils	500–700		
Air	Outside intakes	500		
Air	Filters	300		
Air	Heating coils	500		
Air	Suction connections	800		
Air	Fan outlets	1,300–2,000		
Air	Main ducts	1,000–1,300		
Air	Branch ducts	600–900		
Air	Branch risers	600–700		
Water	Double-pipe exchanger	100–400		Ammonia condenser
Water and waste	Horizontal sewer	150	Pitch, ⅛–¼ in. per ft.	Minimum
Water	Rubber hose	600		Fire hose
Water	General	240–600		600 may cause hammer
Water	Turbine pump suction	60–150		
Water	Mains	120–300		
Water	Condenser cooling	540		Freon condenser
Water	Boiler feed	360–780		
Water	Condenser tubes	180–600		
Water	Hydraulic power	2,100–3,000		
Water	Concrete pipe	900		Max. permissible
Water	Pump valves	180–240		
Water	Pump suction	240		
Water	Large sprinkler lines	300–360		
Water	Pump discharge	240–480		Power plants
Water	Open canal	90–360		Type important
Ammonia gas	Compressors	5,000 suction	ΔP cuts capacity	Max. permissible
Ammonia gas	Compressors	6,000 discharge		Max. permissible
Ammonia gas	¾–2-in. dia.	2,000–3,500		Suction lines
Ammonia gas	2–12-in. dia.	3,500–5,000		Suction lines
Ammonia gas	¾–2-in. dia.	2,500–4,000		Discharge lines
Ammonia gas	2–12-in. dia.	4,000–6,000		Discharge lines
Aqueous ammonia	Piping	30–50		Pump suction
Aqueous ammonia	Piping	100–250		Pump discharge
Brine	Piping	100–200		Pump discharge
Carbon dioxide	Piping	100–1,200		
Methyl chloride	Piping	1,000–2,500		
Sulfur dioxide	Piping	1,000–2,000		Small lines
Freon 12	Compressor discharge	1,800 normal	3 psi.	Min., 750 horiz.,
Freon 12	Compressor suction	2,000 normal	3 psi. max.	1,500 vertical
Freon 12	Liquid lines	180–300	3 psi. max.	
Chimney gas	2–12-ft. dia.,	1,200–3,000		Power plants
City gas	Piping	300	0.3 in. WG/100 ft.	
Oil	Hydraulic systems	420–900		
Oil	Turbine lubrication	150–240		Inlet
Oil	Turbine lubrication	42–60		Outlet
Lead-bismuth	High-temperature heater	240–300		Eutectic mixture
Mercury	High-temperature heater	60–190		
Dowtherm vapor	High-temperature heater	3,600	1 psi/100 ft.	
Arochlor	High-temperature heater	120–900		Above 300 F.
Viscous liquids	Pump valves	100 or less		
Vapors/liquids	Entrainment separators	50% of sonic velocity		Cent. separators
Combustion gases	Furnace breechings	960–1,440		

Answer to Test Your CEQ

By the First Law

$$dE = dQ - dW \quad (1)$$

Taking 1 lb. of gas as the basis and substituting for E and W in (1) yields

$$c_v\,dT + Mc_d\,dT = 0 - P\,dV \quad (2)$$

Now, $$PV = RT \quad (3)$$

where for our purposes R is on a mass basis. Differentiating,

$$P\,dV + V\,dP = R\,dT \quad (4)$$

Combining (2), (3) and (4)

$$c_v\,dT + Mc_d\,dT = (RT/P)\,dP - R\,dT \quad (5)$$

Now, $$c_p = c_v + R \quad (6)$$

Combining (5) and (6)

$$(c_p + Mc_d)\,dT/T = R\,dP/P \quad (7)$$

Integrating between limits

$$(c_p + Mc_d)\ln(T_2/T_1) = R\ln(P_2/P_1) \quad (8)$$

Taking antilogarithms

$$(T_2/T_1)^x = (P_2/P_1)^R \quad (9)$$

where $x = c_p + Mc_d$. Either (8) or (9) suffices as the desired relationship, but to obtain a form analogous to that in the problem statement, we can combine (9) with (6) and the definition of γ to yield

$$(T_2/T_1)^{(\gamma/\gamma-1)+K} = P_2/P_1 \quad (10)$$

where K is the quantity Mc_d/R.

Dr. Sam Sideman of the Israel Institute of Technology suggested a prototype of this problem to me a few years ago.

Looking for practical ADSORPTION know-how?

Call on PITTSBURGH!

IF you'd like an evaluation of your present adsorption system . . . or help in determining how continuous carbon adsorption can be effectively applied in your processing operations, call for a Pittsburgh Technical Service Representative.

His training and experience enables him to offer practical solutions to your present adsorption problems. If you're embarking on a pilot test, he's equipped to help your people set up a laboratory scale column system to demonstrate applicability and efficiency of Pittsburgh Carbons.

Versatile, coal derived Pittsburgh Granular Activated Carbons in continuous column systems have dramatically increased efficiency and lowered costs in a wide variety of adsorption processes including purification, decolorization, deodorization and catalysis. And they may be able to do the same for *you*.

Tell us about your adsorption requirements on your letterhead today or call for a Pittsburgh Technical Serviceman . . . he has adsorption "know-how."

Want More Information?
Send for this Booklet

There's a type of Pittsburgh Granular Carbon ideally suited to solve your particular adsorption problem. Write for folder describing Pittsburgh Activated Carbons in both liquid and vapor phase applications . . . it's free.

ACTIVATED CARBON DIVISION
PITTSBURGH CHEMICAL CO.
GRANT BUILDING PITTSBURGH 19, PA.

A Subsidiary of PITTSBURGH COKE & CHEMICAL CO.

1737

No. 58: A.C. Electric Motors

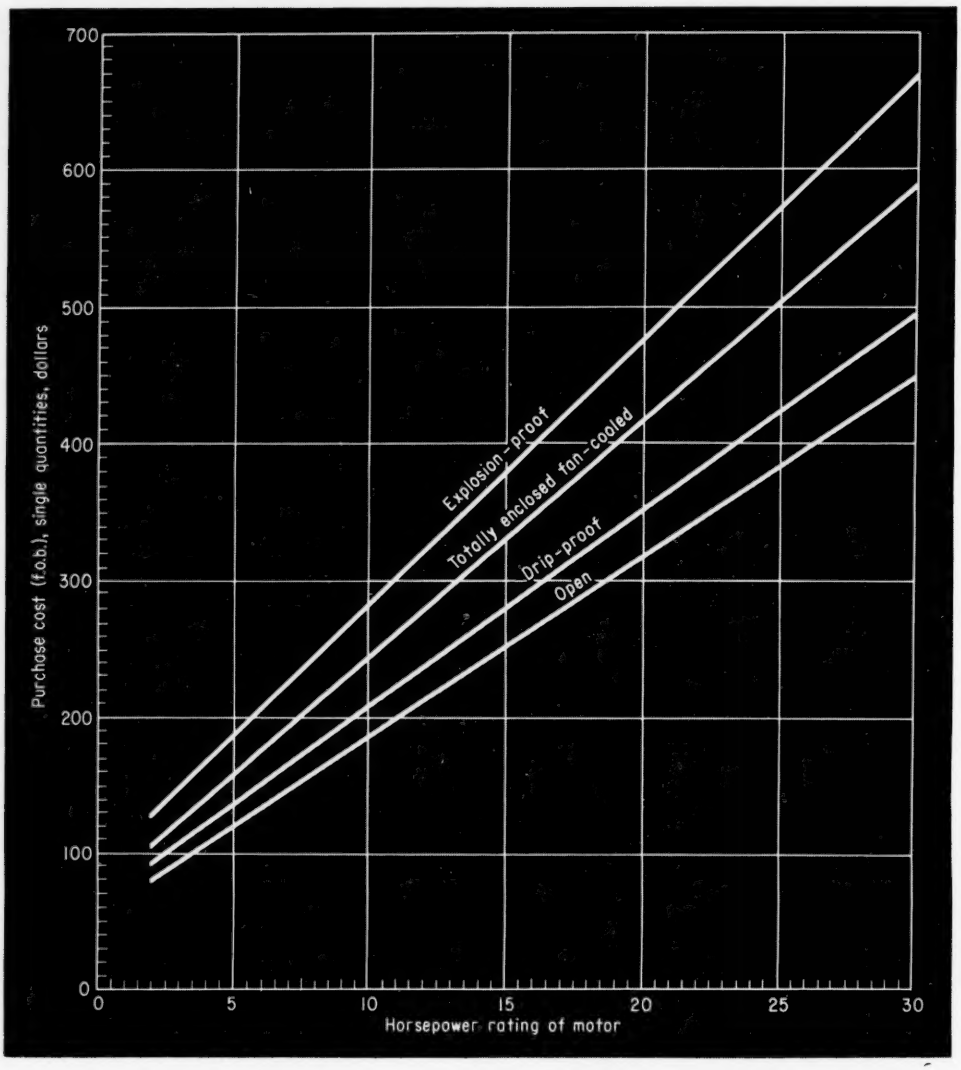
WILLIAM SHULMAN, *Chemical Engineer, Engineering Command, Army Chemical Center, Md.*

A variety of electric-motor drives are used in the chemical process industries. Hazardous process conditions call for one type of motor, mild conditions permit use of another.

We have collected purchase-cost data on four motors —explosion-proof, totally enclosed fan-cooled, drip-proof, open. Cost File 14 (*Chem. Eng.*, Sept. 21, 1959, p. 164) covered cost of totally enclosed fan-cooled equipment. The curves presented here permit a quick comparison between motors, while Cost File 14 contains details on one type.

The curves represent straight-line functions of the cost of ball-bearing, 1,725 to 1,800-rpm., 3-phase, 220/440-v. motors vs. horsepower. Costs are for single quantities, f.o.b.

Data from the curves should not deviate more than 10% from actual costs. Reference date for the data on the graph is June 1961.



Measure Anything from Ether to Asphalt

Have you considered that your company can save important money by using modern measurement methods to control the flow of industrial liquids? With *low cost* Rockwell meters you can guard your liquid inventories. You can batch, blend and control formulas. You'll have accurate records of costs. And with Rockwell meters fitted to Rockwell *automatic control valves* you can save time and money on repetitive operations.

We invite you to investigate all the advantages of liquid metering in your plant. Rockwell meters are sold by leading jobbers everywhere.

INDUSTRIAL METERS
another fine product by
ROCKWELL

Write us for his name or just use the handy coupon. Rockwell Manufacturing Company, Dept. 130K, Pittsburgh 8, Pa. In Canada: Rockwell Manufacturing Company of Canada, Ltd., Box 420, Guelph, Ontario.

Clip Coupon—Mail Today

Rockwell Manufacturing Company
Pittsburgh 8, Pennsylvania

Gentlemen:

I am interested in measuring_____
(NAME OF LIQUID)

Pipe Size_____

Working Pressure_____psi • Temperature_____°F max.

Max. Flow Rate_____gpm • Min. Flow Rate_____gpm

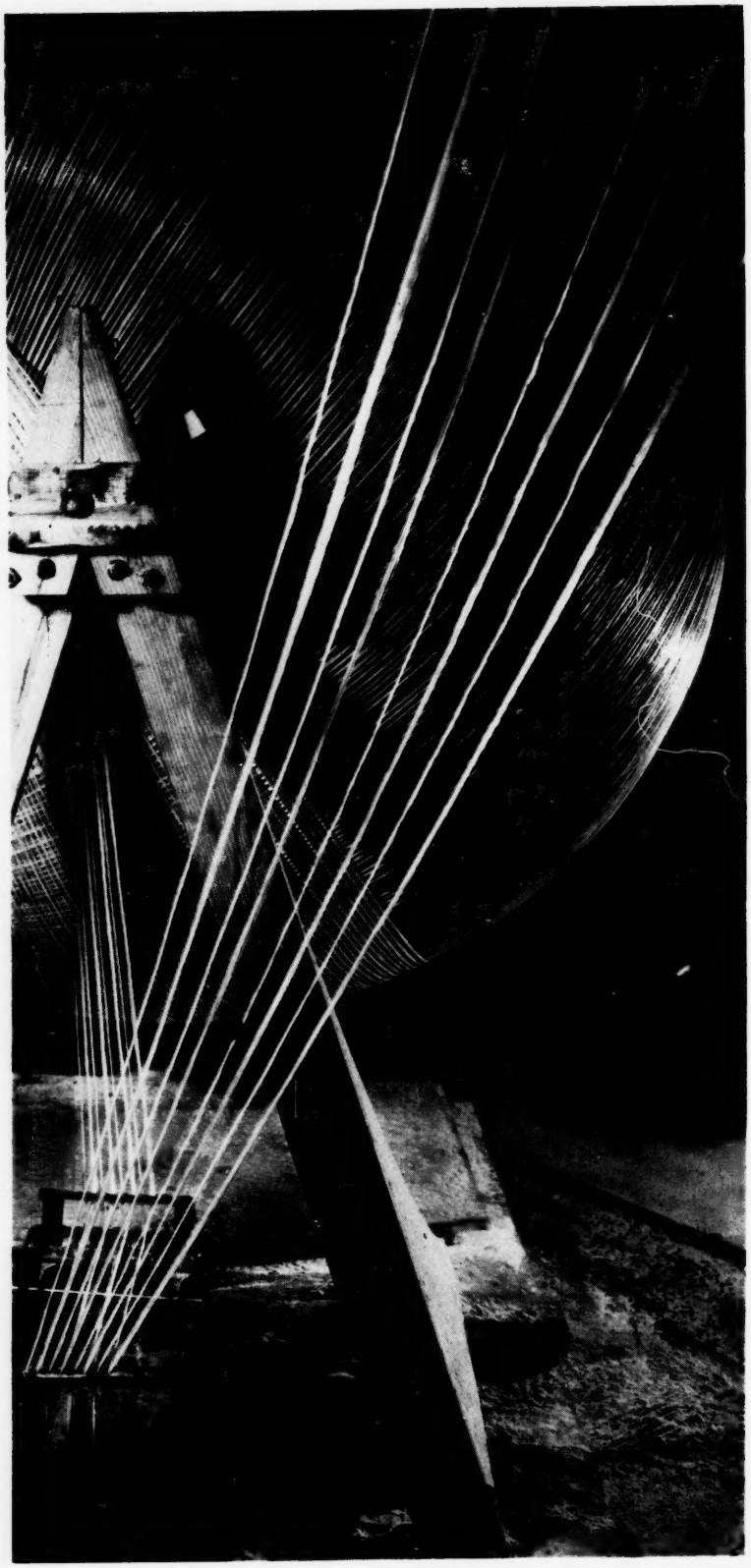
Your Name_____

Company_____

Street_____

City_____ Zone____ State_____

Spheres For Chemical Storage



Hollow ball, constructed of fiber-glass and plastic, provides economical means of chemical storage.

A spherical storage or process tank has a number of advantages over the conventional cylindrical tank, but until recently such items were not generally available to the process engineer.

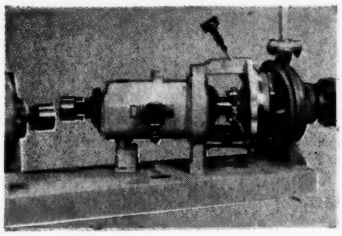
However, developments in chemical-resistant plastics and in techniques of filament-winding have enabled Justin Enterprises, Inc., of Cincinnati, Ohio,* to mass-produce such spherical tanks at a relatively low cost. Designed especially for chemical applications, they have been tradenamed "Chemispheres."

▶**Why a Sphere?**—The sphere, by virtue of its geometry, has certain innate advantages. One of its attributes is minimum surface area per unit of volume. Another is its lack of particular areas of stress concentration. Obviously, a sphere will drain perfectly, and, having no corners, is particularly easy to clean. Its smooth, uniformly

* In November 1961, Justin plans to move to Fairfield, Ohio.

Some fundamentals of centrifugal pump design for the chemical process industries

Booths 520-532 at the Chem Show New York City Nov. 7-Dec. 1



The primary pump problems in the chemical industry involve materials of construction, gland and seal leakage, and bearing failure. Unless pumps are specifically designed for chemical service, unless materials of construction are selected to handle specific corrosive conditions, unless maintenance is simple and parts standardization is high your pumps may be the biggest headache in your entire operation.

Materials of construction

DURCO has spent 50 years developing alloys and materials for practically any corrosive service.

Pumps and pump parts are available in fourteen standard and many special corrosion resistant alloys. All of these are cast in the Durco foundry to retain complete responsibility for the excellence of your equipment.

Chlorimet 2	Ductile iron
Chlorimet 3	18-8-S (304 s.s.)
Durco D-10	18-8-S-Mo
Durichlor	(316 s.s.)
Duriron	Monel
Durimet 20	Nickel
Durcon (modified epoxy resin)	Ni-Resist #2
	Inconel

Specific design for Chemical Service

Shaft run-out and deflection have been the major causes of seal deterioration, gland leakage and bearing failure in pump operation. DURCOPUMPS have shafts with diameters substantially larger than those traditionally used in centrifugal pumps. Shafts have a maximum run-out of .0015" with centerline deflection of no more than .005" at the impeller under maximum hydraulic load. Bearing housings are a thru-bore design, assuring perfect alignment. With this minimum deflection, packing and mechanical seals last far longer under operating conditions.

Long bearing life

Reduced shaft deflection has made it possible to build Series H pumps for 3500 rpm operation. Heavy duty bearings are selected for a minimum life of two years at this speed under maximum operating stress. The normal life is many times greater than this. Bearings are sealed against oil leakage and external contamination by Durco designed Teflon* lip seals.

Many additional features designed into the Series H Durcopump give maximum flexibility in service. The casing is end suction, top center discharge and self venting with integral feet. Since it uses a rear cover closure, the pumping unit can be removed without disturbing the casing or disconnecting the process piping. *No drilled holes enter the casing at any point.*

Impellers are threaded into the pump shaft, eliminating the impeller nut, and thereby greatly reducing the required NPSH. Head and/or capacity for any pump may be changed merely by changing the impeller diameter. A horizontal seal ring permits adjustment of the impeller without increasing stuffing box pressures.

By the use of an adapter between the casing and bearing housing, eight pump sizes can be mounted on one bearing housing, utilizing one shaft. As a result, just four bearing housings will handle the complete range of Durcopumps. Since each is engineered for the maximum pump size in its range, most Durcopumps will have a built-in safety margin far beyond normal service requirements.

Simplified Maintenance

Simplified, low-cost maintenance results from maximum parts interchangeability and minimum down-time.

Bearing housings, shafts, and frame adapters on all Durcopumps are interchangeable over a wide range of pump sizes. A complete range of pumps can be maintained in your plant with a surprisingly small spare parts inventory.

The foot mounted reverse casing design was first applied to chemical pumps by Durco. This design holds process down-time and maintenance costs to a minimum. Pumps are designed for single trade maintenance. A millwright or mechanic can remove all rotating parts of a Durcopump from the casing in a matter of minutes. Neither the piping nor the motor need be disturbed. This means that rebuilt or new assemblies can be installed with little or no realignment.

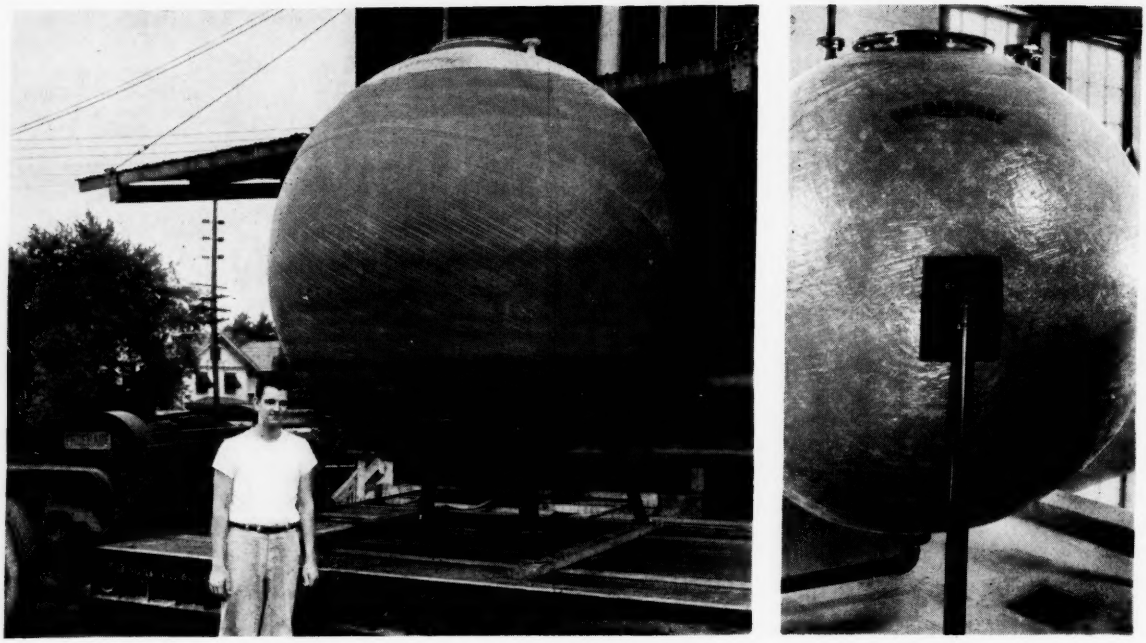
Durcopumps are available in sizes from 1" x 1" to 10" x 8" with capacities from ½ GPM to 4250 GPM, and heads to 345 feet. Durco also manufactures self-priming and submerged pumps for most corrosive services.

You will find that your local Durco Engineer is a reliable source of information on pumping problems and equipment.

**DuPont registered trademark*

THE DURIRON COMPANY INC., *Dayton, Ohio / Serves the process industries*

DURCO



Chemisphere (left) in welded angle-iron cradle, ready for shipping, and (right) on pipe-leg support.

curved inner surface obviates the danger of crevice corrosion.

Fiber-glass spheres are not new, but their use has heretofore been confined to high-cost special applications such as missile components, high-pressure bottles and the like.

▶ **Spherical Winding** — Strength and durability of the Chemisphere is obtained by a spherical winding technique. In this procedure, continuous filament fiber-glass strands are impregnated with resins and wound on a spherical surface in predetermined geodesic patterns. Filament-winding of a Chemisphere is somewhat analogous to the winding process used in the manufacture of baseballs and golf balls.

Presently, Justin is making two standard sizes, 6 and 8 ft. dia. (A third, 10 ft., size is planned.)

▶ **Corrosion Resistance**—The Chemisphere is constructed with a special liner, within the fiber-glass and plastic sphere, for corrosion resistance. The standard liner is Atlec 382 bisphenol A polyester, a plastic that is resistant to a large variety of chemicals. (See *Chem. Eng.*, Apr. 3, 1961, p. 182 and June 12, 1961, p. 272 for specific data on bisphenol A polyester.)

▶ **Fabrication** — Filament-winding is still very much of a "black art" and companies in the field are highly reluctant to reveal any of the details of their processes. The photograph on p. 142 shows one stage in the winding process. The fiber-glass rovings are seen entering the picture at the top right, are soaked in plastic in the trough at the lower left, and are then wound on the spherical form.

Justin will not reveal just how the openings are fabricated into the tank, but states that pipe nipples and manholes are constructed and installed in such a way that the corrosion resistance of the barrier coat is carried through each fitting to the outside flanged surface.

▶ **Design Data**—The 6-ft. sphere weighs 230 lb., has a capacity of about 850 gal., and lists at $585. The 8-ft. model weighs 400 lb., holds slightly over 2,000 gal., and costs $900. The projected 10-ft. Chemisphere will hold approximately 5,000 gal.

Wall thickness of both sizes is roughly ¼-in. Pressures up to 30 psi. can be withstood. (Higher pressures may be feasible, but Justin is still collecting pressure-test data, and is unwilling to make further recommendations at present.)

Temperatures can go up to 250 F., depending on the specific application.

These data relate to the "standard" model, which uses a lining of bisphenol A polyester. For special applications, such as higher pressures, higher temperatures, etc., other materials (e.g., epoxy) can be used.

▶ **Installation**—The Chemisphere is provided with a pipe leg support, or with a cradle support such as those shown in the pictures above. The cradle is recommended because it provides a secure shipping support. (It costs $85 additional, for either size.)

The spheres may be used on the level, in the usual manner, or they may be stacked one above the other to save space. If the specific application requires it, they may even be buried underground.

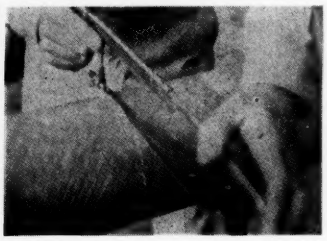
THE SURPRISING ECONOMICS OF BONDSTRAND®

...the pipe designed for corrosive chemicals

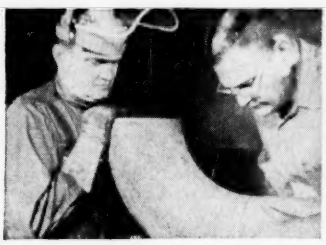
A 20′ length of 6″ schedule 40 carbon steel pipe weighs 398 lbs. Crane required for lifting.

A 20′ length of 6″ Bondstrand pipe weighs only 60 pounds. One man can lift and carry.

Cutting steel pipe takes four (or more) times longer than Bondstrand.



Bondstrand is cut with ordinary hacksaw. Preheating not required.



Two men required to bevel, clean, position, center and level a 90° elbow before welding.

Only one man required to apply adhesive and position a 90° Bondstrand elbow. It aligns itself.

Welder and helper required to tack weld, check alignment, make stringer weld and grind, make flush weld and grind again, make cover weld, grind and wire brush.

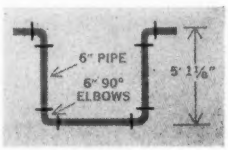
One man with a hammer and a two-by-four makes the Bondstrand Quick-Lock joint in a matter of seconds. Important: **Bondstrand pipe may be handled immediately; no waiting for adhesive to cure.**

IT TOOK 65 MINUTES TO WELD ONE ELBOW TO STEEL PIPE. ONE MAN MADE THE SAME ASSEMBLY WITH BONDSTRAND IN ONLY 10 MINUTES!

BONDSTRAND, the fiber glass reinforced epoxy pipe, handles nearly every corrosive solution—acids, salts, alkalies—used in industry today. It will withstand pressures up to 550 psi and temperatures up to 300°F. So will the complete line of BONDSTRAND fittings, 2″ through 12″.

The smooth, abrasion-resistant inner surface permanently retains its excellent flow characteristics (Hazen-Williams formula C=150) and thus often permits use of one-size-smaller diameter pipe. BONDSTRAND is only one-eighth the weight of steel and because it resists exterior as well as interior corrosion it does not require continual maintenance painting.

BONDSTRAND versatility is unmatched by any other pipe—metallic, thermoplastic, glass or lined. What does this superiority cost? Less than you may suspect. Here is how BONDSTRAND compares with carbon steel in this simple pipe layout:



TOTAL COST OF MATERIAL AND LABOR

Schedule 40 **Carbon Steel** Pipe With Welding Elbows **$225.63**

Series 4000 **Bondstrand** Pipe With Bondstrand Elbows **$287.40**

Figures shown are from a strict time-and-cost study conducted by one of Southern California's leading independent piping and engineering firms.

This means that in this layout you get all the advantages of BONDSTRAND for only 21.7% more than ordinary carbon steel pipe. (In complex process piping, BONDSTRAND can actually cost less.) In Schedule 40 stainless steel, which approximates BONDSTRAND's chemical resistance, the layout would cost $1,287.50—*348% more than* BONDSTRAND!

To evaluate the superiority of BONDSTRAND *pipe for your specific requirements, write for complete technical data.*

Amercoat® CORPORATION 136

Export Div., 4809 Firestone Blvd., South Gate, California

2851 Fisher Ave., Evanston, Ill. | 360 Carnegie Ave., Kenilworth, N. J. | 111 Colgate Ave., Buffalo, N. Y. | 2404 Dennis St., Jacksonville, Fla. | 6530 Supply Row, Houston, Tex.

ACID ATTACK?

You're safe with Lapp Chemical Porcelain Valves!

Now you can valve acids as easily as water! The solid porcelain of these Lapp valves is chemically inert, immune to corrosion from all acids (except hydrofluoric), and absolutely impervious. There's *extra* protection, too, in the TUFCLAD® armor that cushions the porcelain body against impact and insulates it against thermal shock.

Best of all . . . Lapp Chemical Porcelain Valves cost you far less than corrosion-resistant alloys and lined equipment. And they practically never need maintenance or replacement.

There's a full line to fit your process . . . Y-Valves and Angle Valves, in ½" to 6" sizes. Also safety valves, check valves, plug cocks, pipe, fittings (to 8" diameter), and special shapes.

WRITE *for Catalog 567.*
Lapp Insulator Co., Inc.,
1922 Chestnut Street, LeRoy, N. Y.

Lapp
CHEMICAL
PORCELAIN

CPI NEWS BRIEFS . . .

Continued from Page 68

plant in Vicksburg, Miss., by the end of the year. To produce nitrate of potash and byproduct chlorine, the facility marks Southwest's initial venture into chemicals. Plant will use a new, company - developed process to manufacture the agricultural-grade product.

Air Reduction Pacific Co. plans to more than double capacity at its Richmond, Calif., air separation plant. New rating will be 200 tons/day of liquid nitrogen, oxygen and argon, with nitrogen the principal product. Completion is set for next March.

Offices

Visco Products Co., a Nalco Chemical Co. subsidiary that produces chemicals for the oil industry, has formally opened new offices and laboratory at Sugar Land, Tex., 20 miles southwest of Houston. Laboratory includes facilities for researching emulsion breakers, microbiology, water treating, corrosion, scale and oxyalkylation.

The Dow Chemical Co. has opened a district sales office in Honolulu.

E. H. Sargent & Co., distributor of scientific instruments, apparatus and chemicals, has opened a western division office at Anaheim, Calif.

California Corp. for Biochemical Research, Los Angeles, has opened a branch office in Bethesda, Md. Calbiochem makes a wide range of research biochemicals.

Companies

Urethane Industries International, Inc., has been created by merging Midwest Foam Products

Co., Evanston, Ill., and Shelley Urethane Industries, Inc., Los Angeles. Both manufacture and fabricate polyurethane. New firm will be headquartered in Evanston.

Metal & Thermit Corp., New York, and **The Udylite Corp.**, Detroit, may merge. Directors of both firms have approved; stockholders must now take action. Udylite shareholders would get 0.65 shares of M&T common for each share they now own. Udylite would become a division of M&T.

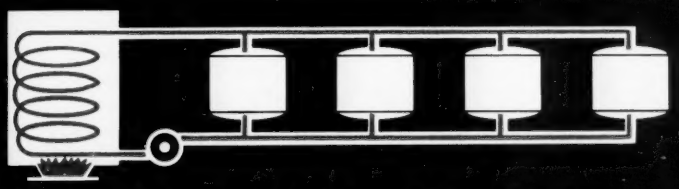
Atlantex Corp., Somerville, Mass., has acquired **Scientific Engineering Laboratories, Inc.**, manufacturer of high-vacuum equipment in Berkeley, Calif. Atlantex serves the Northeast area with research and control instrumentation in the fields of electronics, physics and optics.

Diamond Alkali Co., Cleveland, has acquired Fiber Chemical Corp., Cliffwood, N. J., through an exchange of stock. Fiber Chemical makes organic chemicals and inorganic specialties, has annual sales of about $1.5 million. Its founder and president, F. F. Axelrad, becomes director of research and development for the firm, which Diamond will operate as a subsidiary.

The Chemstrand Corp., producer of Acrilan acrylic fiber and nylon yarns, has purchased an interest in Blume Knitwear, Inc., manufacturer of Helen Harper sweaters and coordinates. Chemstrand's vice president of marketing says the move "provides Chemstrand with an opportunity to establish a framework within which to explore new techniques and new products."

Kermac Potash Co. has been created by Kerr-McGee Oil Industries, Inc., Oklahoma City, and National Farmers Union Service Corp., Denver. New company will mine and mill extensive potash reserves near Carlsbad, N. M. Specifications for a projected 1,500-ton/day potash plant are being "finalized" in a pilot-plant program just

FOR + MAXIMUM EFFICIENCY



Systems operating on Monsanto *Thermal Fluids* deliver process heat up to 600° F. from unpressurized *liquid*

SAVE BIG! Now, with Monsanto *Thermal Fluids*, you can install a process heating system that will generate up to 20 million BTU per hour and deliver the heat as an unpressurized liquid to multiple use points! Needs no vapor traps, gas blankets, pressure piping, vaporizers, condensers, or other fancy "gadgets." Needs no costly, space-filling safety devices. No water conditioning; no pressure danger; no fire danger—*you do not need a licensed engineer to operate a Thermal Fluid system!*

SPEED OUTPUT! With heat delivered via a liquid *Thermal Fluid*, you cut maintenance to the bone (no corrosion, no fouling of tubes, pipes, pumps, or coils); heat evenly (*no hot spots*); control temperature on-the-button (*to within 2° F.*). Result: better quality resins, foods, pharmaceuticals, dyes, hydrocarbons, chemicals—*plus* increased production (*in some cases up to 50% more*)!

SAFETY, TOO! You can forget worrying about fire and explosion! Monsanto *Thermal Fluids* won't support combustion. Can't even be ignited by the direct flame of a blowtorch!

This recent report tells the safety story:

"My operator fired the gas heater but failed to start the circulation pump. The coil overheated and ruptured. The Monsanto fluid poured into the firebox. There was a lot of smoke, of course, but no external fire. And as soon as the heater was cut off, the smoking stopped immediately!"

Mail This Handy Coupon Today for Design Engineering Data

MONSANTO CHEMICAL COMPANY
Organic Chemicals Division
Dept. 4468-W, St. Louis 66, Mo.

Monsanto

Please send me: ( ) Technical Bulletin 1248 on Monsanto *Thermal Fluids;* and ( ) list of heating system designers and heater manufacturers.

NAME .....

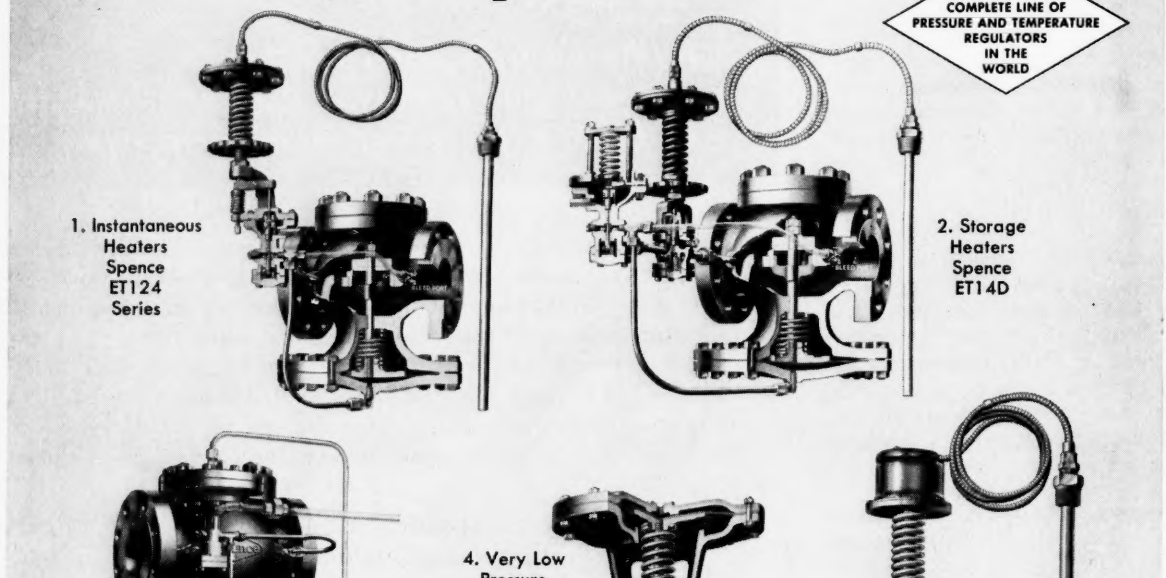
COMPANY .....

STREET .....

CITY ..... *ZONE* *STATE* .....

How to Select Automatic Regulating Valves For Temperature Control

THE MOST COMPLETE LINE OF PRESSURE AND TEMPERATURE REGULATORS IN THE WORLD


1. Instantaneous Heaters Spence ET124 Series
2. Storage Heaters Spence ET14D
3. Air Control Systems Spence EAT Series
4. Very Low Pressure Differentials 2″ Through 8″ Spence G2T40
5. Very Low Pressure Differentials Up Through 2″ Valves Spence Direct Acting T2
Spence

During the past year, our field representatives have reported many cases of improperly, and uneconomically, applied temperature regulators. To help you avoid some of these costly mistakes, here are a few tips on selecting the most effective and economical temperature regulating valves for your applications.

1. Instantaneous heaters require a special action for close temperature control and freedom from hunting. In the Spence ET124 series, steam pressure is modulated according to temperature (demand) and is automatically regulated at any pressure established by the demand.
2. Storage heaters, on the other hand, are more economically controlled by the Spence ET14D, which includes a simple temperature-actuated pilot that opens and closes the main valve to maintain a constant temperature.
3. Air control systems can now have a ±5°F control accuracy under wide and instantaneous load swings with the Spence EAT regulator. Engineers report savings of up to 50% in installed costs with this recently developed Spence cascade system when it has been used in place of conventional instrumentation.
4. For the combination of very low pressure differentials and air or water control, Spence recommends Type G2T40. This single seated valve provides fast, positive response in 2″ through 8″ valves. Double seat Type G22 is also available in 10″ through 12″.
5. When very low pressure differential is encountered with valves of 2″ or less, the Spence direct operated T2 is recommended. The sensitive vapor tension thermostat responds quickly to small changes in bulb temperature for continuous, accurate control.

In this brief description of industrial process and heating temperature control, we have given a few important tips in proper regulator selection. If you would like more detailed information on these control applications, write for the new Spence Temperature Control Bulletin IV 1014. SE-150

SPENCE ENGINEERING COMPANY, INC.
Walden 1, N. Y.
Paulsen Spence, P. E., President

launched at Kerr-McGee's metallurgical research laboratory in Golden, Colo.

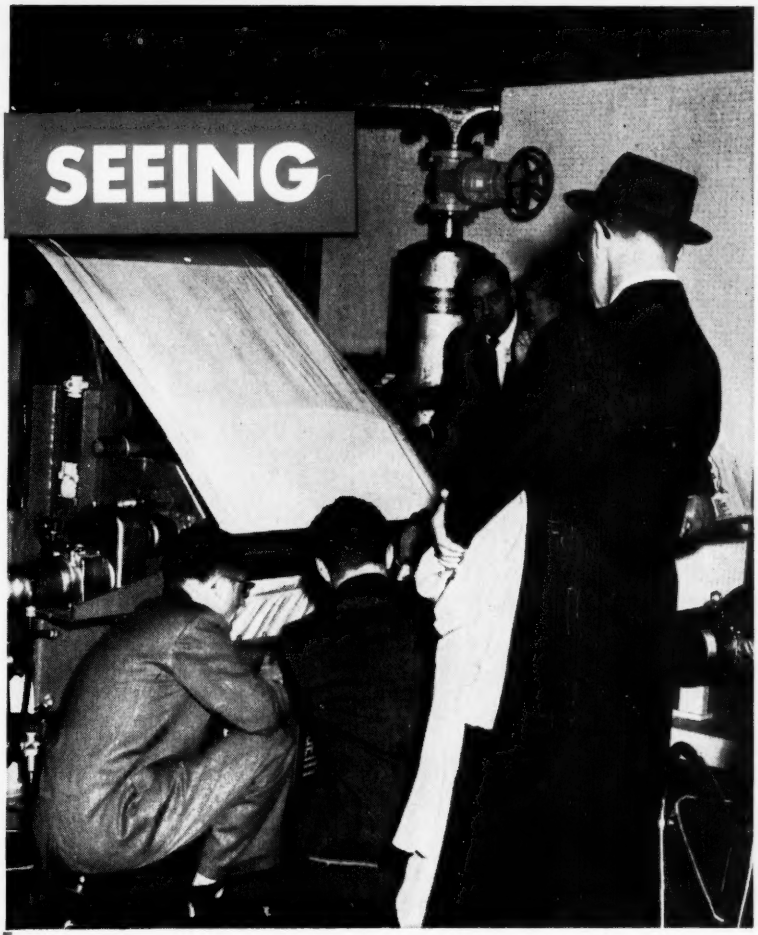
International

France: Societe d'Energie Nucleaire Franco-Belge des Ardennes (SENA) has awarded contracts for its 242,000-kw., underground nuclear power plant at Chooz, near the Belgian border in France's Ardennes region (*Chem. Eng.*, Sept. 5, 1960, p. 176). Scheduled for completion by 1965, the closed-cycle water reactor has been advanced $8 million in financing by Euratom. Contracts went to the U. S.'s Westinghouse Electric International Co., Belgium's Ateliers de Constructions Electriques de Charleroi, and France's Framatome. SENA is equally owned by Electricite de France (the French national utility) and Centre et Sud (a group of six Belgian private utilities).

Great Britain: Imperial Chemical Industries Ltd. has begun production of a new high-tenacity polypropylene filament yarn called Ulstron, described as the strongest polypropylene yarn being made. Development of the product followed Montecatini's grant to ICI of the British manufacturing and sales rights in August 1960. First full-scale plant will have capacity for 5 million lb./yr., scheduled to go on stream at Wilton by the end of the year. As the market warrants, new facilities will be built at the firm's Kilroot, Northern Ireland, site.

Netherlands: Hercules Powder Co. N.V. has dedicated a 30-million-lb./yr. resin derivatives plant at Zwijndrecht. Output includes rosin size for the paper industry, rosin emulsifiers for synthetic rubbers, and synthetic resins for such diverse end-products as protective coatings, adhesives, ink, and floor coverings.

Spain: Desarrollo Quimico Industrial S.A. has been created by



is the best answer

There is no quicker and better way to learn of new developments – to compare their relative merits—to get new ideas that may cut costs and improve your products – than to actually SEE what's new at the Exposition of Chemical Industries.

Your limited time will be well spent in studying the fact-filled displays of over 500 leading manufacturers of process equipment, materials handling, chemicals and raw materials, laboratory equipment and supplies, control instruments and automation.

Keep informed—plan your visit now, and bring your associates with you. It will more than pay you for the modest investment in time. Write for free advance registration. 2779

28th EXPOSITION OF CHEMICAL INDUSTRIES

N. Y. Coliseum, Nov. 27—Dec. 1, 1961

MANAGEMENT: International Exposition Company, 480 Lexington Ave., N. Y. 17, N. Y.

HIGH VISCOSITIES SLOWING YOU UP?

. . . use a

MARASPERSE*

highly effective, low cost dispersant
(usually in dry powder form)
to reduce viscosity to the desired consistency

Only a little Marasperse is needed to reduce slurry viscosities, or to prevent micron-sized particles from settling out of suspensions. Usually less than 3%, based on the weight of the solids in the aqueous system, will do the job for you.

For example, manufacturers of gypsum board require just 0.15% Marasperse in their stucco slurries to give them more fluidity at lower water contents . . . And producers of pesticide wettable powders include but 1.5% to 2.0% Marasperse in their powders to ensure satisfactory dispersion in spray tanks. What's more, the Marasperses cost only a few cents a pound!

Tell us about your viscosity problem. If it's typical of one of the many that the Marasperse dispersants have licked, we'll give you specific information based on user experience. If it's something new or unique, we'll tell you how to test samples of the Marasperses to determine whether or not they'll be useful to you.

MARATHON
A Division of American Can Company
CHEMICAL SALES DEPARTMENT
*Registered U. S. trademark MENASHA, WISCONSIN

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Please send Information File No. E101 ☐, Samples ☐ of MARASPERSE for use in

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CPI NEWS BRIEFS . . .

Du Pont and Energia e Industrias Aragonesas S.A., Madrid, to make dithiocarbamate fungicides. Subject to approval by the Spanish government, firm will build a plant at Sabinanigo in the Pyrenees, products of which will include fungicides to control mildew, leaf blights and fruit rots. Facility is expected to be in operation next year.

Great Britain: Cyanamid of Great Britain, Ltd., has brought its melamine plant on stream at Gosport, Hampshire. Annual output is expected to be about 3,000 tons.

People

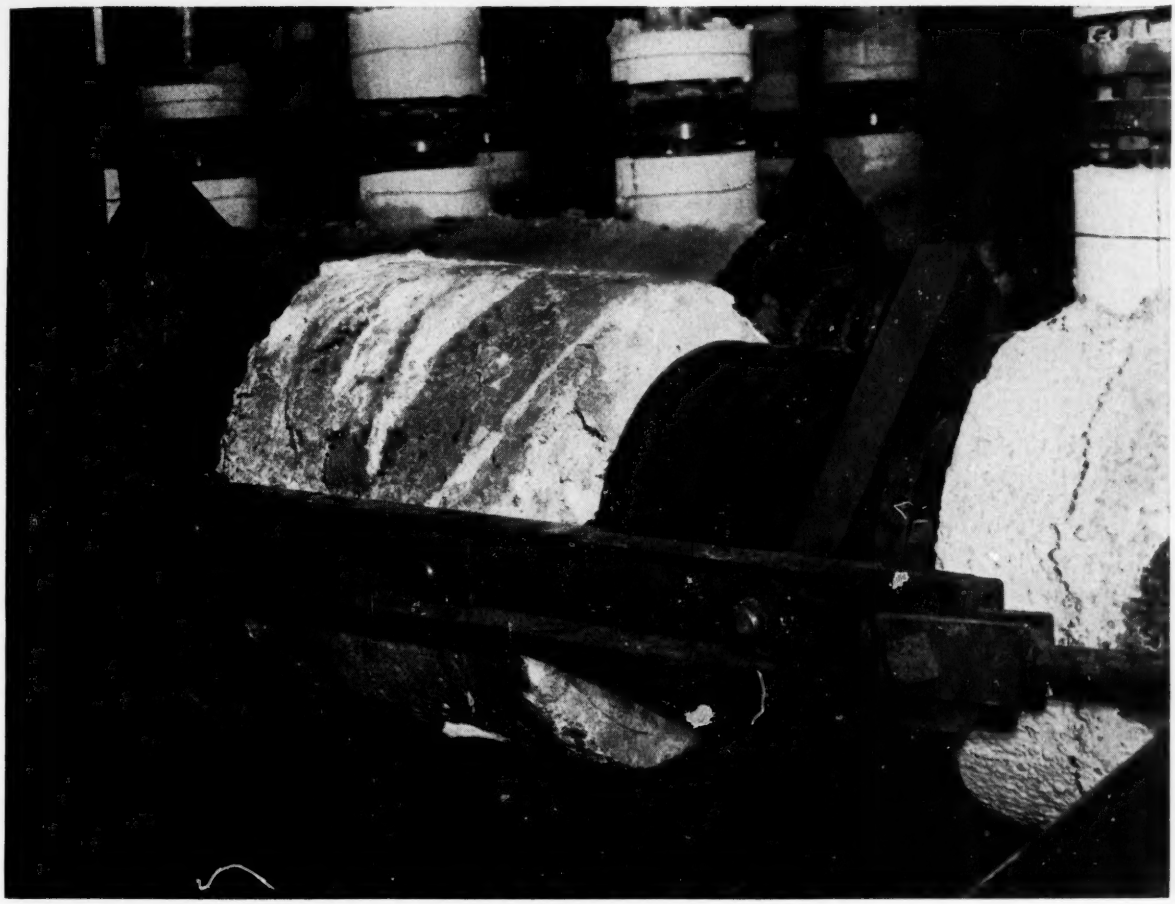
Kenneth C. Laughlin is the new assistant to the director of research and development of fibers at Allied Chemical Corp.'s National Aniline Div.

Warren L. McCabe has been named acting head of the department of chemical engineering at Polytechnic Institute of Brooklyn. He succeeds **Donald F. Othmer,** who requested to be relieved of his administrative duties after 24 years as department head. Othmer was subsequently awarded the newly created rank of Distinguished Professor of Chemical Engineering, "in recognition of meritorious and illustrious accomplishment."

Gordon Rozand has been named director of manufacturing for Cary Chemicals Inc.

Edward A. Knaggs has been appointed director of research at Stepan Chemical Co.'s Industrial Chemicals Div.

Douglas H. Ewing has been elected vice president of American Management Assn.'s Research and Development Div. He is vice president and technical director of Radio Corp. of America's David Sarnoff Research Center in Princeton, N. J.



Sixty 10, 12 and 14 in. Zallea Expansion Joints absorb expansion in lateral headers, and deflection due to downcomer expansion.

WHEN TEMPERATURES ARE REALLY HIGH, YOU NEED THE

maximum reliability of Zallea Expansion Joints!

These expansion joints are so hot they glow. Yet, 60 of them have been in service for over 7 years without a single failure! The temperatures are so high (our customer prefers not to say just how high, but the cherry-red glow will help you guess), that spares were purchased for the job in anticipation of short expansion joint life. The spares? They are now in similar service at a newly expanded facility.

This is just one more example of customer confidence created by Zallea performance . . . the kind of performance you can expect when Zallea design and application specialists sit down with your engineers to tackle a tough expansion joint problem.

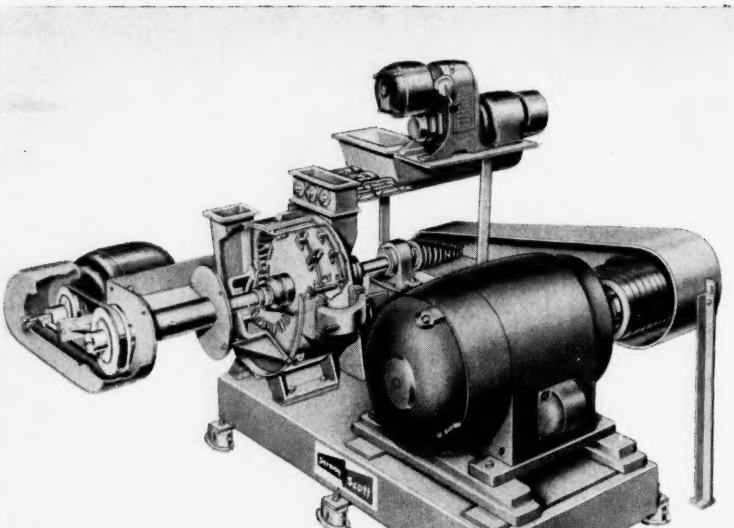
Our work with virtually every engineering and manufacturing firm in the process field has given us an unequalled background of experience and engineering capabilities . . . experience that can save you time and money when it is brought to bear on your specific problems.

Write for Catalog 56. It contains comprehensive engineering data for expansion joints from 3 in. to 50 ft. dia., pressures to 3600 psi, temperatures to 1600 F . . . Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

Zallea

for maximum reliability

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS



PULVOCRON—Efficient Impact and Air Attrition Pulverizer with Internal Particle Size Classifier.

Pulverize to Desired Particle Size in One Quick Operation!

Whether your product is hard or soft, brittle or pliable, natural or synthetic, *Strong-Scott's Pulvocron* will reduce the particle size of your material to specifications. You can easily control size—from a coarse 60 mesh down to an extremely fine range of 95 to 99% less than 5 to 10 microns.

Jacketed chamber allows positive temperature control of pulverized product.

The Pulvocron is constructed of carbon steel or stainless steel and engineered for years of trouble-free service. Two sizes available—20″ and 38″ diameter grinding chamber. Join the many processors who are now using the Pulvocron to increase capacity and control quality.

MAY WE HELP YOU WITH YOUR PROCESSING PROBLEMS?

If you have a processing problem, contact Strong-Scott or our representative. We maintain a Customer Testing Service Laboratory equipped with production size equipment to evaluate the application of our equipment to your process. This service and the confidential test report are provided on a no-charge basis.

For complete information, contact your nearest Strong-Scott representative or write us today.

See the Complete Strong-Scott Line in the 1962 Chemical Engineering Catalog—Pages 909-912

The Strong Scott Mfg. Co.

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Phone: STerling 1-7461

Equipment designed for better Processing

Convention Calendar

November

6-8. Atomic Industrial Forum, Atomfair '61, Conrad Hilton Hotel, Chicago, Ill.

6-8. Chemical Institute of Canada, Chemical Engineering Division Conference, Royal York Hotel, Toronto, Ont.

6-10. American Management Assn., Manufacturing Management Course, AMA Academy, Saranac Lake, N. Y.

7-10. Packaging Machinery Manufacturers Institute, 1961 Show, Cobo Hall, Detroit, Mich.

10. Assn. of Consulting Chemists and Chemical Engineers, "Use of Technical Experts in Legal Work", Pittsburgh Hilton Hotel, Pittsburgh, Pa.

13-15. American Petroleum Institute, 41st Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

14-16. The Material Handling Institute Southwest Show, Dallas, Tex.

15-17. 1961 Eastern Analytical Symposium Statler-Hilton Hotel, New York, N. Y.

26-1. American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York, N. Y.

27-1. 28th Exposition of the Chemical Industries, New York Coliseum, New York, N. Y.

27-1. American Management Assn., Data Processing and Management Information Systems Course AMA Academy, Saranac Lake, N. Y.

28-30. The Building Research Institute, 1961 Fall Conferences, Mayflower Hotel, Washington, D. C.

29-30. University of Michigan, "Effective Utilization of Engineering Personnel" Kellogg Center, East Lansing, Mich.

29-30. Oklahoma State University, Industrial Wastes Conference, Stillwater, Okla.

December

3-6. American Institute of Chemical Engineers, 54th Annual Meeting, Hotel Commodore, New York, N. Y.

3-7. American Institute of Electrical Engineers, Institute of Radio Engineers, Assn. for Computing Machinery, Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C.

4-6. Chemical Specialties Mfg. Assn., Roosevelt Hotel, New York, N. Y.

5-6. Western Petroleum Refiners Assn., Refiners Computer Conference, Hotel Tulsa, Okla.

6-8. American Institute of Mining, Metallurgical and Petroleum Engineers, Iron & Steel Div., 19th Annual Electric Furnace Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

7-8. Society of the Plastics Industry, 9th Plastic Film, Sheeting & Coated Fabric Conference, Pierre Hotel, New York, N. Y.

12-14. Eastern Joint Computer Conference, Sheraton-Park Hotel, Washington, D. C.

18-19. Rensselaer Polytechnic Institute, Materials Research Conference, Troy, N. Y.

26-31. American Assn. for the Advancement of Science, Annual Meeting and Exposition of Science and Industry, Denver Hilton Hotel, Denver, Colo.

January

9-11. American Society for Quality Control, American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn., National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D. C.

22-25. National Plant Maintenance and Engineering Show, Convention Hall, Philadelphia, Pa.

23-26. Canadian Pulp & Paper Assn., 1962 Annual Meeting of the Technical Section, Queen Elizabeth Hotel, Montreal, Can.

24-26. American Society of Mechanical Engineers, 2nd Symposium on Thermophysical Properties, Princeton, N.. J.

29-31. Institute of the Aerospace Sciences, Annual National Meeting, Hotel Astor, New York, N. Y.

30-2. Society of Plastics Engineers, 18th Annual Technical Conference, "Plastics Revolutionize Design", Penn-Sheraton Hotel, Pittsburgh, Pa.

February

6-8. Material Handling Institute, Industrial Truck Assn., Monorail Manufacturers Assn., Early Spring Industry Meeting, Hilton Inn, Atlanta, Ga.

12-15. 12th National Exposition of the Air-Conditioning, Heating and Refrigeration Industry, Great Western Exhibit Center, Los Angeles, Calif.

BIG CAPACITY IN *Small* SPACE

AEROFIN *Smooth-Fin* Heating and Cooling Coils

High ratio of surface area to face area

High air velocities without excessive friction or turbulence

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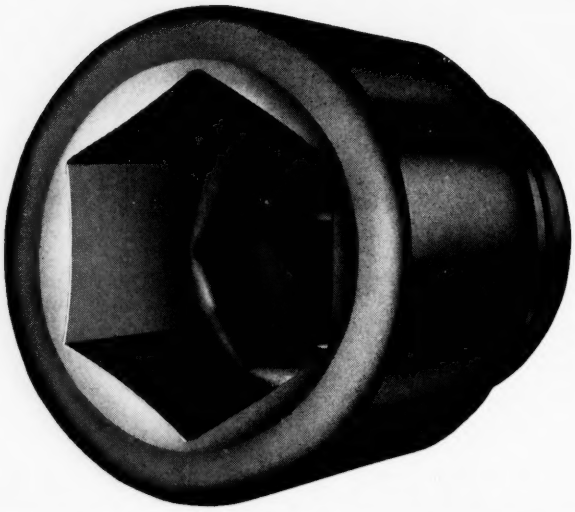
ENGINEERING OFFICES IN PRINCIPAL CITIES

Snap-on

Industrial Sockets



BUILT EXTRA TOUGH... to take a beating

Just ask a SNAP-ON sales engineer about companies that have cut socket breakage and increased output by switching to SNAP-ON. These built-to-take-it industrial sockets have the extra heft, accurate dimension and special steel toughness to stand up to day-in, day-out production and maintenance work. Result: more work hours per socket — far less downtime due to socket failure.

Wide range to fit your needs!

SNAP-ON sockets are built in a wide range of sizes in ¼-in., ⅜-in., ½-in., ¾-in., 1-in., 1½-in., 2½-in. and 3½-in. square drive. Socket varieties include standard lengths, bolt clearance lengths, thin-wall types, magnetic sockets; special shapes for self-tapping screws and tapered hex nuts; semi-flexockets and full flexockets; plus a full range of extensions and handles.

Talk sockets with your SNAP-ON man. He's a tool specialist who can offer competent advice on what's best for you in SNAP-ON's complete range of industrial sockets. Be sure to specify if sockets are for hand use or for power nut running or for power impact use. SNAP-ON makes different sockets for all these uses.

Service as near as your phone!

SNAP-ON industrial wrenches and mechanic tools are quickly available from stock warehoused at regional industrial and branch sales offices. You get fast action on regular or emergency needs. Write now for new 180-page industrial catalog.

FOR ALL INDUSTRY

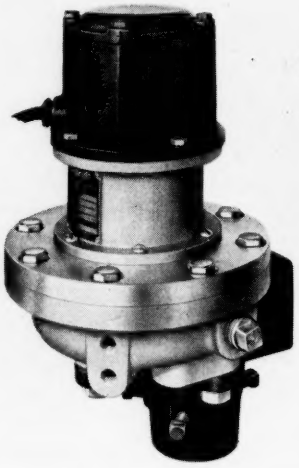
SNAP-ON TOOLS

8106-J 28th AVENUE • KENOSHA, WISCONSIN

NEW EQUIPMENT . . .

(Continued from page 80)

special requirements, porous carbon or porous stone filter tubes are available.—**Sethco Mfg. Corp., Merrick, L. I., N. Y.** **80D**



Gas density cell

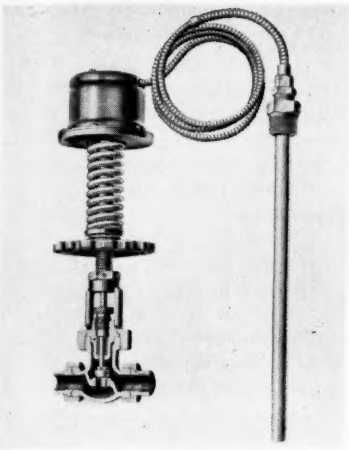
Mass flow of gas determined with density and pressure differential.

An instrument that provides continuous measurement of gas density makes it possible to determine mass flow of gas. It produces a differential pressure directly proportional to density; this measurement when combined with a pressure differential across a primary device provides the information for the mass flow calculation.

In operation, gas is drawn into the sampling chamber at line pressure, which is measured at a high-pressure differential connection. Rotating in this chamber, a hollow spinner creates a suction that draws gas through the spinner tube from an opening at its center.

This suction pressure is connected to the low-pressure differential connection: the difference between high and low pressure is a true index of gas density. The differential-pressure instrument may be located up to 50 ft. away.

The cell measures densities up to 7.8 lb./cu. ft.—**The Foxboro Co., Foxboro, Mass.** **154A**

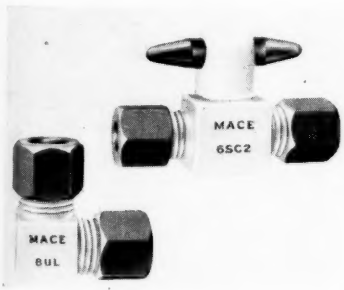


Temperature regulator

Direct-operated device controls small loads at low pressure.

A new direct-operated temperature regulator economically controls small loads with very low pressure differentials, says the maker. It is specifically recommended for pressure differentials of less than 3 psi.

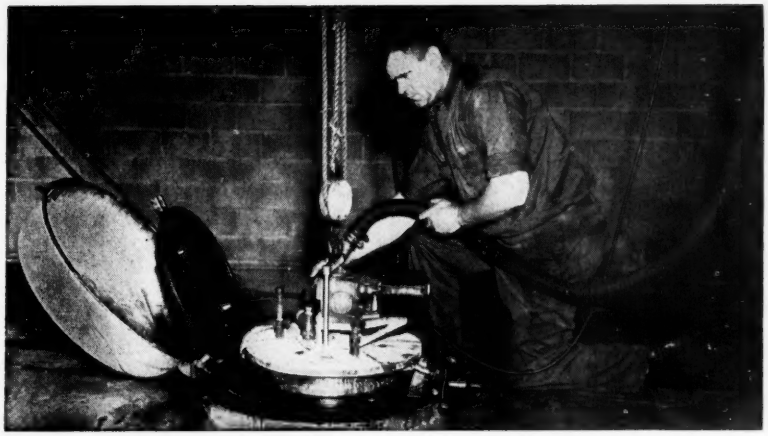
Sizes up to 2-in. are available with bronze body and union ends. Vapor tension thermostats are supplied for the temperature range of 50 to 250 F. Single-seat construction and stainless steel trim are said to provide tight, positive shutoff.—**Spence Engineering Co., Walden, N. Y. 155A**



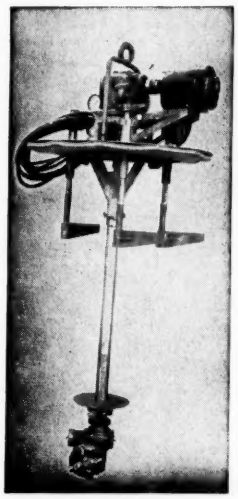
Teflon equipment

Valves, stopcocks, tubing fittings are pressure-molded, machined.

Tight sealing on glass, metal and plastic tubing is possible with units from a new line of all-Teflon valves, stopcocks and fittings.



This man, cleaning a tank-truck interior of alkyd resin deposits, accomplishes



Oakite Interior Tank Cleaning Unit, Model 531. Automatically sprays hot cleaning solution under pressure. Nozzles rotate vertically and horizontally. Rinses after cleaning. Sprays 45 gal/min at 150 lbs. pressure.

18 hours cleaning in 1 hour

At a New England chemical plant, it used to take three men working six hours to clean out each truck tank—two men inside the tank scrubbing, scraping and sloshing, one man astride the dome to watch in case the oxygen tanks gave out. Even at that, a careful inspection was needed to make sure the tank was properly clean.

That's how it *was*. Now, one man equipped with the Oakite 531 Interior Tank Cleaning Unit, using a cleaning solution recommended by the local Oakite representative, does the whole job in one hour flat. A sweet job, too, with the tank interior shining like new.

It's just one of the many ways Oakite methods and materials save time and money in chemical plants . . . and why you may find it well worth your while to call in your local Oakite man. Meanwhile, for details about Oakite tank cleaning equipment and Oakite cleaning methods for the chemical industry, write to Oakite Products, Inc., 16H Rector Street, New York 6, N. Y.

Technical Service Representatives in Principal Cities of U. S. and Canada

Export Division Cable Address: Oakite

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over 50 Est. 1909 SCIENCE years' leadership in industrial cleaning

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The man it belongs to wouldn't even lend it to you. He gets into roofing problems regularly, and he wants his Lion Roofing Manual handy.

He knows from experience that it is the first complete roofing manual ever written. He also knows he can find a quick, clear answer to almost any roofing question in its 36 pages.

Here are some of the subjects covered:

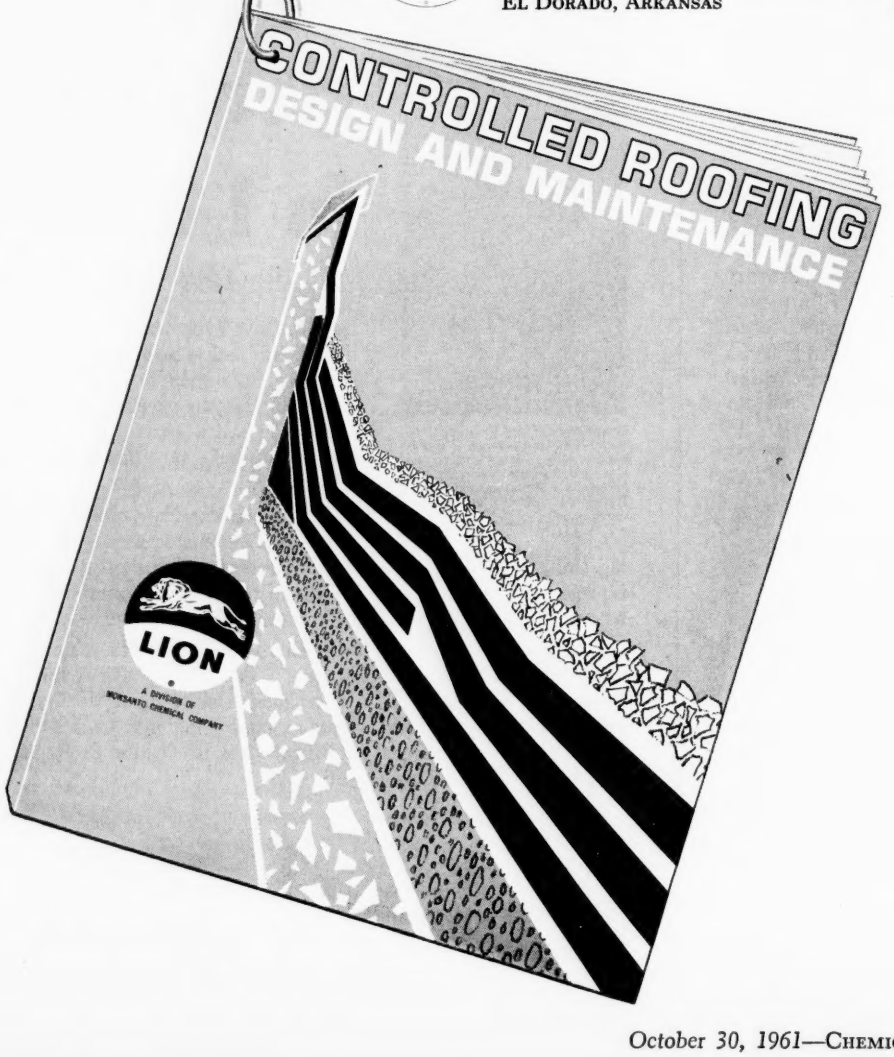
- Roofing System Deterioration
- Vapor Effects
- Stress Effects
- Design Considerations
- Roofing Maintenance
- Cleaning
- Spot Repair
- Recoating
- Reroofing
- Flashings

If the roof over your head concerns you, this manual can be invaluable. Send us your name, and we'll send you a copy to prize, free.

Protective Coatings Division, Dept. PC-11

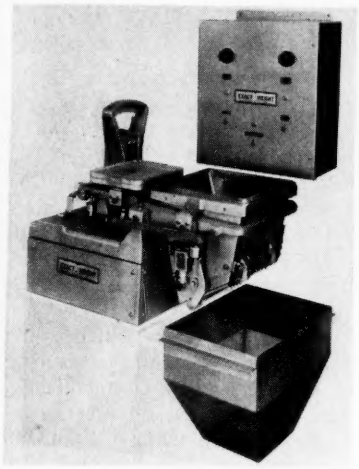
LION OIL COMPANY

A Division of Monsanto Chemical Company
El Dorado, Arkansas



Designed for use in high-vacuum or low-pressure systems (to 15 psi.), the valves and fittings are unaffected by alkalis and all acids except high-temperature fluorine.

Valve design is said to eliminate the need for stem packing. Manually operated units are sized 6, 8 and 10 mm. Electrically operated poppet and rotary valves are available with orifice sizes from $\frac{1}{16}$ to $\frac{3}{8}$-in. Fittings come in 4- through 12-mm. sizes.—**Mace Corp., San Gabriel, Calif. 155B**



Net-weighing machine

Automatic device used separately or with filling, packaging units.

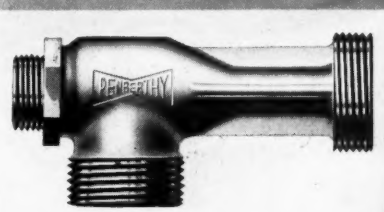
An automatic net-weighing machine with a 75-lb. capacity has a control sensitivity to $\frac{1}{2}$-oz. and a dial that can be read to 1 oz. The pictured unit consists of a heavy-duty lever scale, equipped with an air-operated dump mechanism on the weigh hopper.

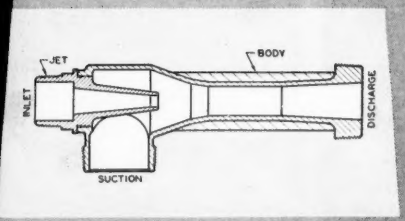
Automatic adjustable controls are mounted on the scale for operating feed equipment such as automatic valves, vibratory feeders or conveyor belts. Optional equipment includes manual or air-operated bag holders, portable stands, counters, alarm systems, and vibratory feeders with one or two rates of speed.

Enclosures and dust-removal systems may be used with the unit. Power requirements are 115-v. a.c. and 60 to 125 psi. com-

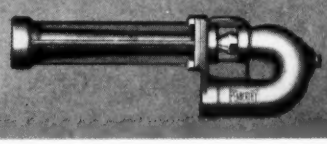
VERSATILITY

for applications unlimited





JET PUMPS by PENBERTHY



There's hardly a basic manufacturing or service industry that hasn't a use for Penberthy Jet Pumps. And the list of OEM products embodying Jet Pump applications is virtually endless, too. Small wonder, for wherever there's a fluid, vapor, gas or slurry handling job to be done . . . aerate, agitate, blend, circulate, dilute, exhaust, filter, heat, mix, pump or transfer . . . there you'll find an application for *versatile* Penberthy Jet Pumps.

And consider the advantages . . . small in size, light in weight . . . construction and operation simplicity . . . low initial cost, low installation cost, little or no maintenance cost. And in many cases Penberthy Jet Pumps can be utilized where mechanical pumps are impractical or uneconomical. Want more information?

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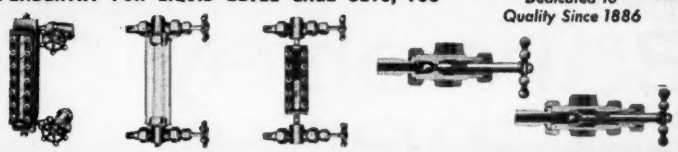

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Barnebey-Cheney is the only manufacturer of
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	natural grain sizes	*pelletized*	*powdered*
nut shells	✔	✔	✔
wood	✔	✔	✔
coal	✔	✔	✔

Ask for literature J-114. Send us your problem to solve.
Barnebey-Cheney, Columbus 19, Ohio.

Barnebey Cheney

pressed air.—**The Exact Weight Scale Co., Columbus, Ohio. 157A**

Briefs

Teflon packing of bleached TFE filament is preshrunk prior to braiding. Designed for applications requiring high peripheral speed, it resists products completely, needs no external lubrication. Available in die-molded packing sets, spools and coils.—**Chemical & Power Products, Inc., New York. 158A**

Nylon pressure tubing is light, strong, and flexible enough so that prebending is unnecessary. Withstands most corrosives at −40 to +185 F., comes in 1,000 and 2,500-psi. grades. Sized from ⅛ to ½-in.—**Garlock Inc., Palmyra, N. Y. 158B**

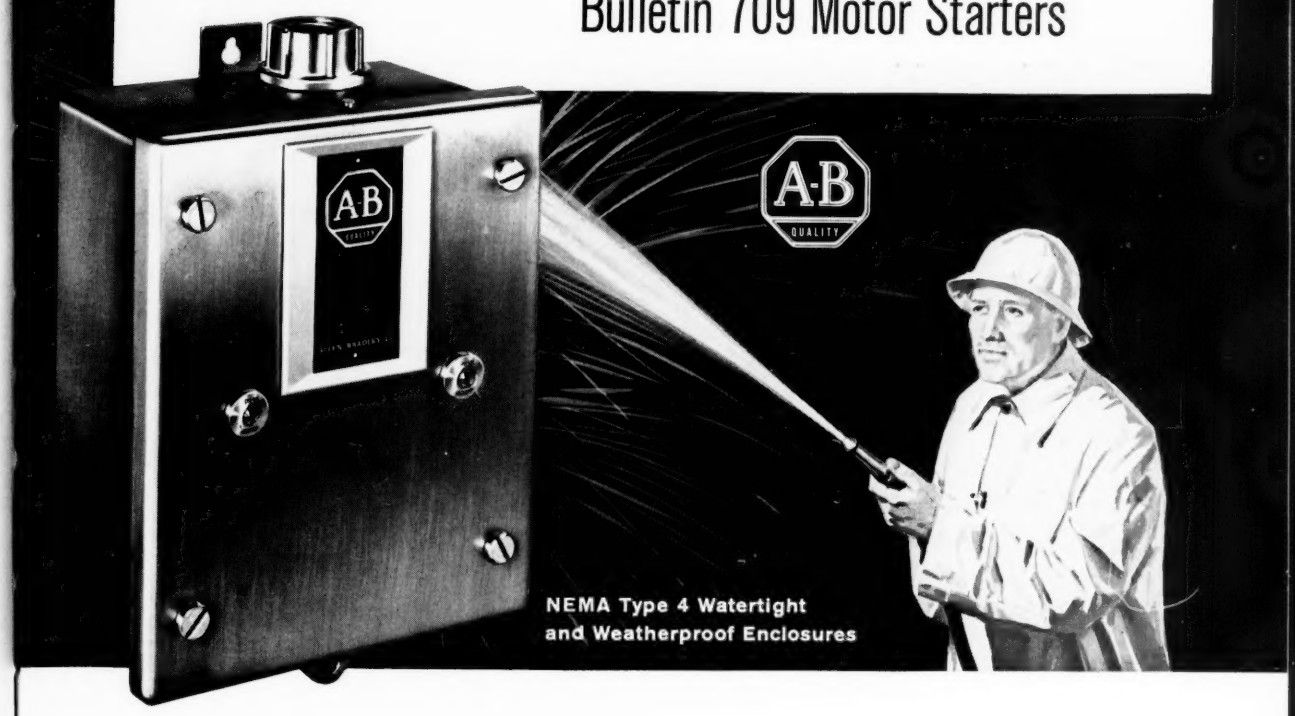
Pulverizer-classifier reduces friable materials to subsieve uniform particles of any desired fineness in the 1-150 micron range. For a wide variety of chemicals, drugs, plastics, etc.—**Bauer Bros. Co., Springfield, Ohio. 158C**

Equipment Cost Indexes . . .

	June 1961	Sept. 1961
Industry		
Avg. of all	236.9	237.2
Process Industries		
Cement mfg.	230.9	231.1
Chemical	237.3	237.7
Clay products	224.4	224.6
Glass mfg.	224.0	224.4
Paint Mfg.	229.4	230.3
Paper mfg.	228.6	229.0
Petroleum ind.	234.8	235.2
Rubber ind.	237.6	238.1
Process ind. avg	235.2	236.2
Related Industries		
Elec. Power equip	235.1	235.8
Mining, milling	238.7	239.2
Refrigerating	268.6	269.1
Steam power	225.0	225.5

Compiled quarterly by Marshall and Stevens, Los Angeles, for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124-6 for method of obtaining index numbers; Mar. 6, 1961, pp. 115-116 for annual averages since 1913.

Allen-Bradley Nema Type 4 STAINLESS STEEL ENCLOSURES for New Bulletin 709 Motor Starters

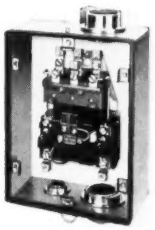


NEMA Type 4 Watertight and Weatherproof Enclosures

Complete Protection Against Water and Weather!

Allen-Bradley's revolutionary, new line of Bulletin 709 motor starters, which includes reversing switches, multi-speed starters, combination starters, etc., is now available in stainless steel enclosures. Thus the benefits of reduced size, increased interrupting capacity, increased life, and longer trouble free operation can be given to all outdoor installations, or where a great deal of moisture is present. Designed for installation in dairies, breweries, meat and food processing plants and similar locations where a daily "wash-up" is required, the "eye appeal" of these stainless steel enclosures will also be an asset.

The standard Nema 4 enclosures are made of heavy gauge Type 302 stainless steel. However, Type 316 stainless steel can be furnished at a correspondingly higher price. There are many other features about these revolutionary starters that will interest you. Therefore, please write for Publication 6100: Allen-Bradley Co., 1316 South Second Street, Milwaukee 4, Wisconsin.



BULLETIN 709 SIZE 2
in watertight, weatherproof Stainless Steel Enclosure—for use where a great deal of moisture is present, such as tanneries, food processing plants, pump houses, dairies, breweries, etc., or in outdoor locations.

20-61-RM

ALLEN-BRADLEY

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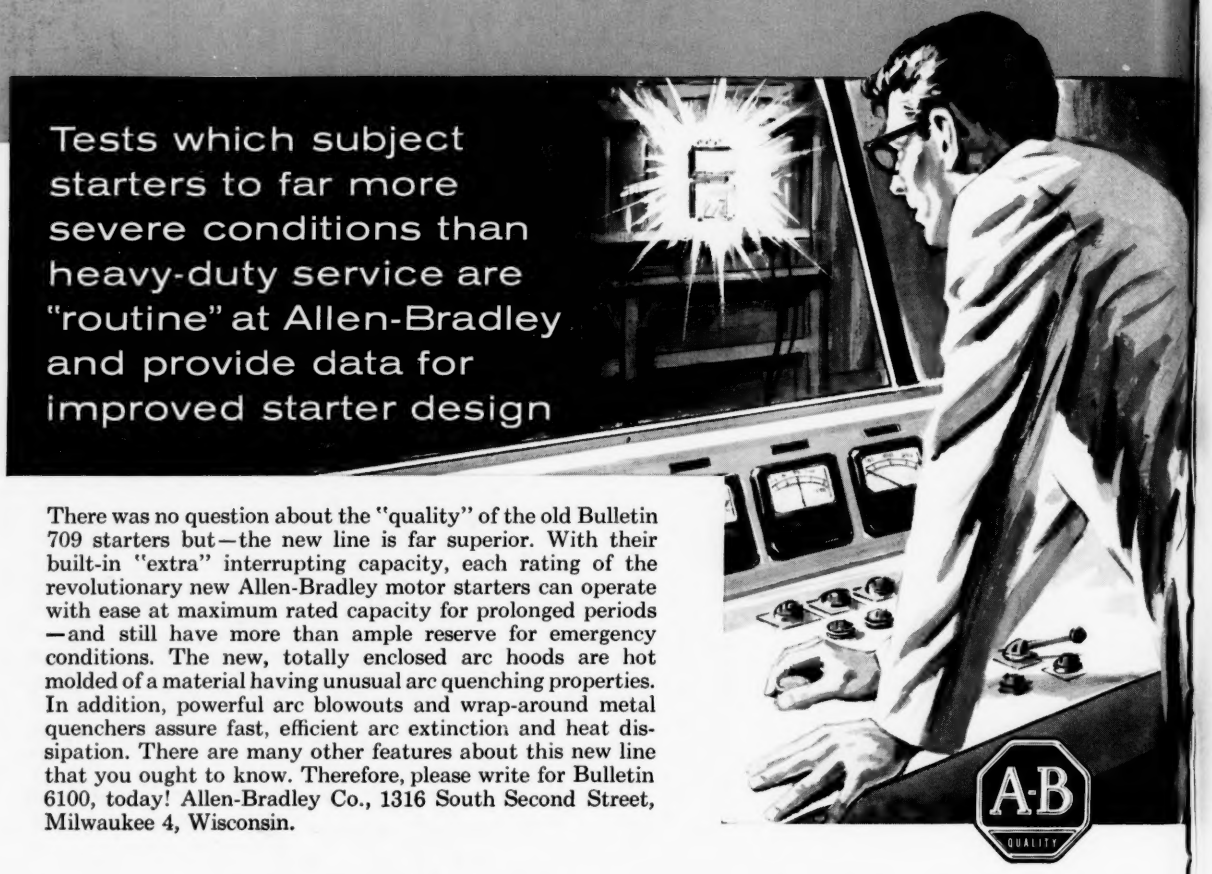
QUALITY MOTOR CONTROL

The Superior "Quality" of the New Allen-Bradley Starters GREW OUT OF DESTRUCTIVE TESTS

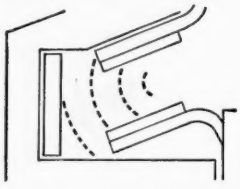


Tests which subject starters to far more severe conditions than heavy-duty service are "routine" at Allen-Bradley and provide data for improved starter design

There was no question about the "quality" of the old Bulletin 709 starters but—the new line is far superior. With their built-in "extra" interrupting capacity, each rating of the revolutionary new Allen-Bradley motor starters can operate with ease at maximum rated capacity for prolonged periods—and still have more than ample reserve for emergency conditions. The new, totally enclosed arc hoods are hot molded of a material having unusual arc quenching properties. In addition, powerful arc blowouts and wrap-around metal quenchers assure fast, efficient arc extinction and heat dissipation. There are many other features about this new line that you ought to know. Therefore, please write for Bulletin 6100, today! Allen-Bradley Co., 1316 South Second Street, Milwaukee 4, Wisconsin.

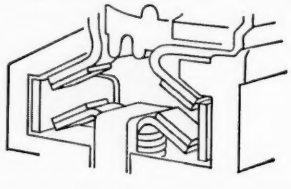
Here's How EXTRA Interrupting Capacity Is Built Into All Allen-Bradley Starters

Powerful Arc Blowout



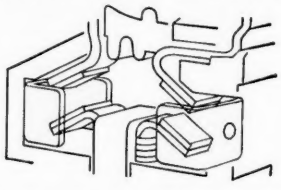
The powerful magnetic field, generated between the contacts when an arc is drawn, forces the arc off the end of the contacts. It is quickly cooled and extinguished by the large surfaces of the hood.

Totally Enclosed Chambers



A new, unusually strong and stable material is hot molded to extremely close tolerances. Each chamber of the arc hood is totally enclosed. Thus, the usual effects of ionization and heat are greatly minimized.

Metal Arc Quenchers

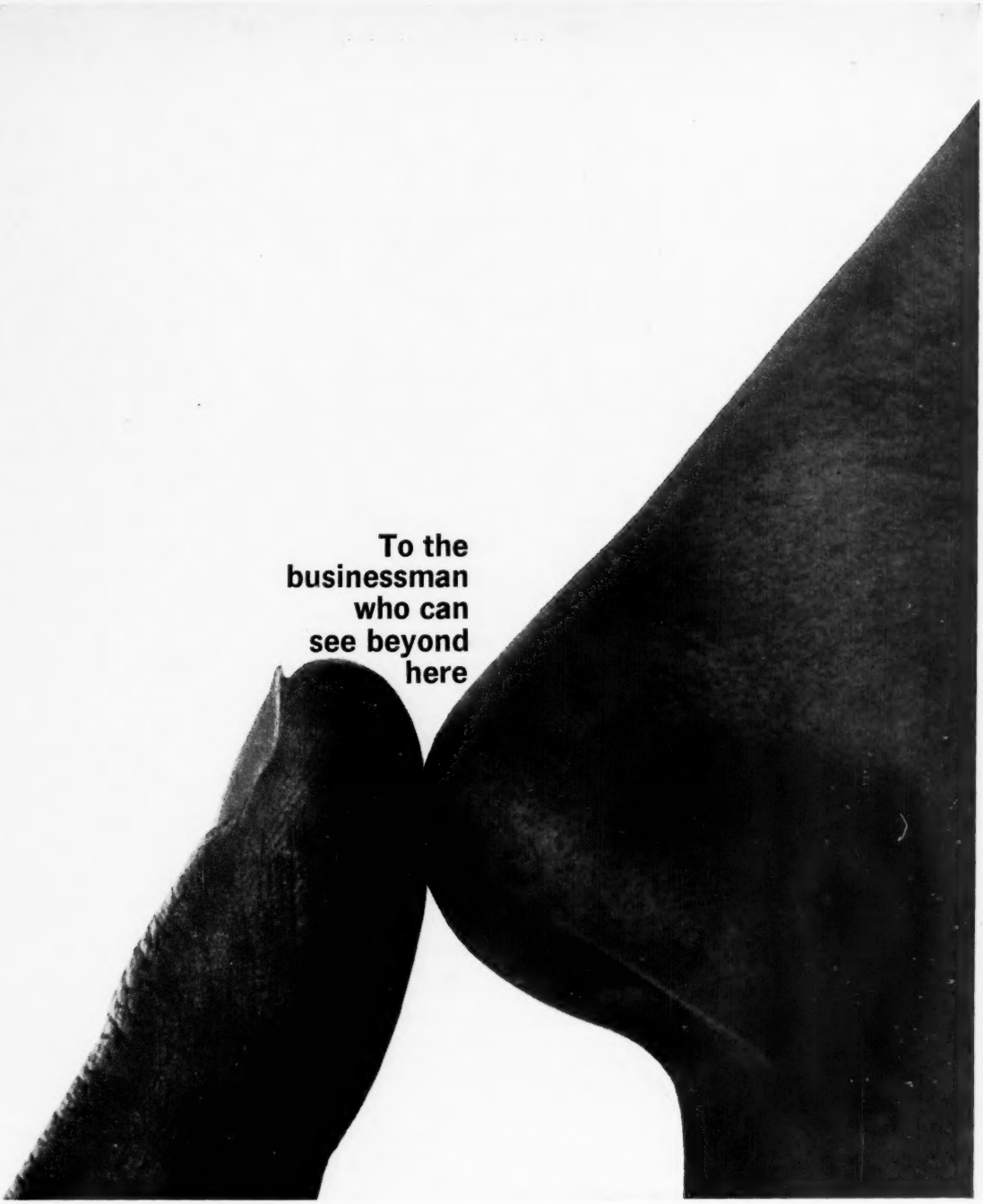


Size 2 starters and the higher ratings have metal quenchers in both the front and back of each arc chamber. This efficient construction gives the arc no chance to become destructive.

20-61-RM

ALLEN-BRADLEY

QUALITY MOTOR CONTROL



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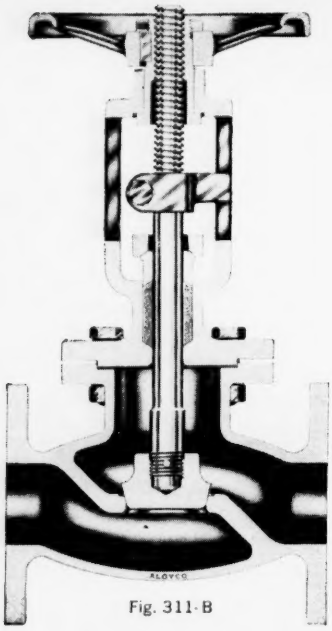

Fig. 311-B

7 ADVANTAGES OF THE NEW ALOYCO GLOBE VALVE DESIGN!

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- No galling between seat and disc.
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- No spinning of disc.
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For more information on these Aloyco valves of Stainless Steel and other corrosion resistant alloys, write for Bulletin #7, Alloy Steel Products Company, Inc., 1301 West Elizabeth Avenue, Linden, New Jersey. 1.10

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WELL-COVERED

ORGANIC COATING TECHNOLOGY. VOL. 2. BY H. F. PAYNE. WILEY. 724 PAGES. $17.50.

Reviewed by Kenneth Tator, Kenneth Tator Associates, Coraopolis, Pa.

With Volume 1 to complete the unit, this work will be of real interest to two types of chemical engineers: those working in paint-manufacturing plants or other plants producing materials used in paint manufacturing; and those maintenance engineers in any industry within whose area of responsibility falls plant and equipment protection by paint maintenance.

Volume 2 is not complete in itself being but a continuation of Volume 1. Therefore, both are reviewed here.

Volume 1 covers the film-forming mechanism and the film-forming materials, concluding with a chapter on testing methods, both for the raw materials and for the finished coating. Volume 2 completes the sequence of coating components by continuing for something more than one-third of its bulk into a complete discussion of coating pigmentation. The remainder of the book deals with the principles of coating formulation and paint manufacture, ending with a very full discussion of formulation for, and properties of, both decorative and protective coatings in various end-uses; for residences and institutions, product finishing and industrial maintenance.

As the treatment is complete and in a logical presentation, it is possible that these volumes could be used as a basic text for acquainting one's self with coating technology, but in practice it would be much easier to obtain the elementary instruction from other sources and use these for reference and advanced instruction. In this capacity of reference, the reviewer feels they are currently unexcelled. They are comprehensive in their coverage, well indexed, and replete with literature references for additional study.

All discussions, where possible, are illustrated by typical formulations, and in this the author has continued into Volume 2 the daring innovation of Volume 1 of using the trade names of those commonly used compounding materials.

For the chemical engineers engaged in the production of paint or paint materials, here is a valuable reference. For maintenance engineers who are interested in learning more about the potentials and limitations of the paints they are currently using (or more than can be obtained from sales literature of the paints they are asked to buy), these volumes are equally recommended.

OF DIRECT UTILITY

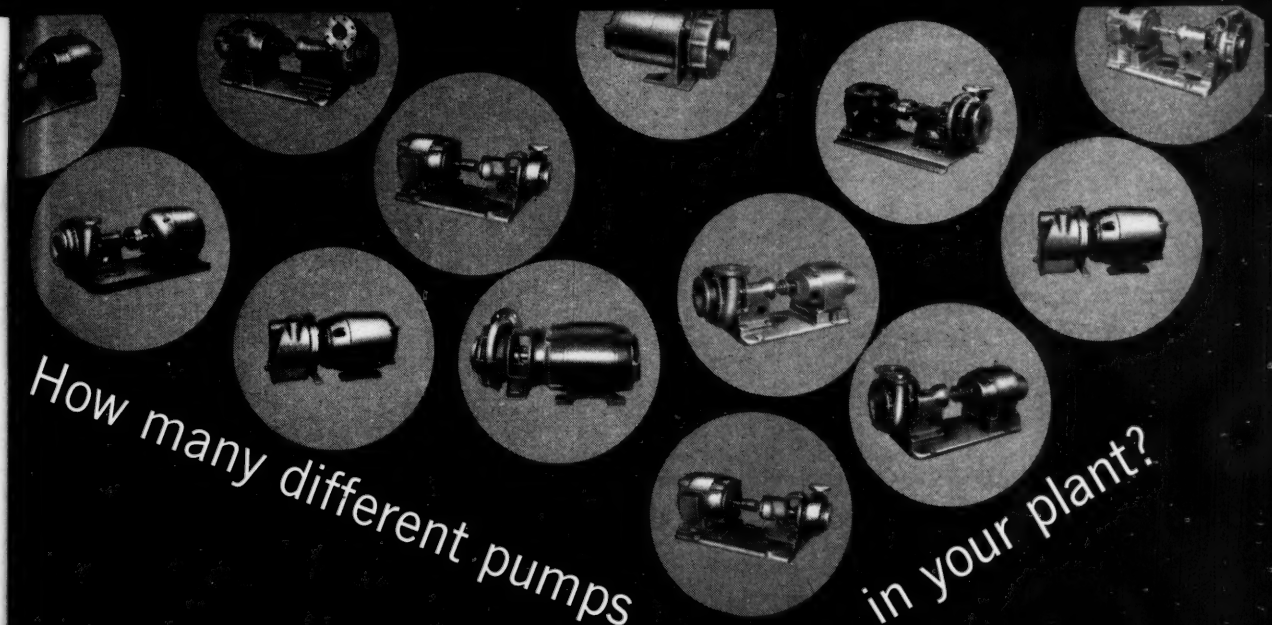
HANDBOOK OF FLUID DYNAMICS. ED. BY V. L. STREETER. MCGRAW-HILL. 1,215 PAGES. $24.

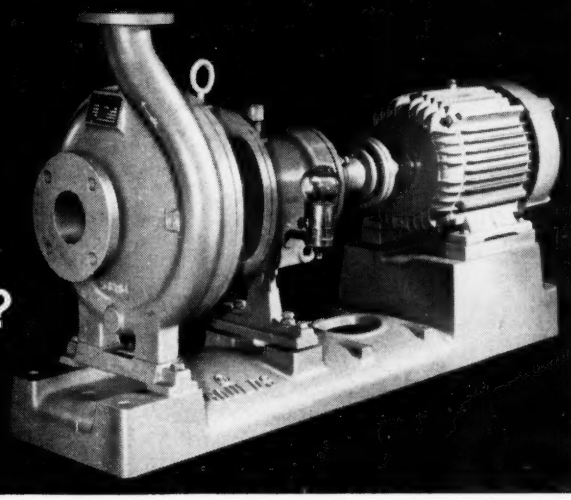
Reviewed by Robert R. Rothfus, Carnegie Institute of Technology, Pittsburgh, Pa.

In the past, books on the subject of fluid dynamics have tended to reflect one of two viewpoints. They have either dealt broadly with the range of topics pertinent to a particular discipline, or have probed a certain aspect of the field without much reference to its interactions and relationships. Now, the features of both methods of approach are combined in a single handbook.

The term "handbook" is misleading in a sense, for the 27 sections are actually separate treatises, each written by a generally well-known expert who develops his subject thoroughly. Occasionally an aspect is legitimately approached in different ways by different contributors, but this serves to enhance the value of the presentation to readers who have a firm background in the overall subject of fluid flow. It is not necessary to be a specialist in order to understand the material in a particular section, but specialists can find much that is important and useful, since the various topics are covered in detail.

Each section stands largely by itself; about half of the book is devoted to fundamental concepts, the rest has to do with applications in various fields. Most of the sub-





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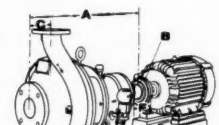

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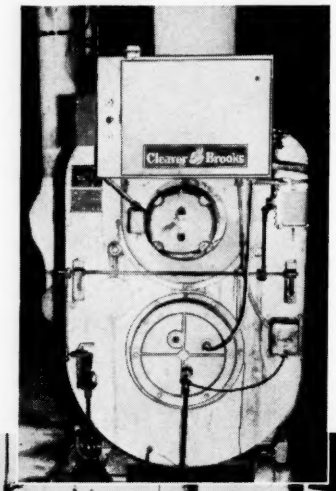

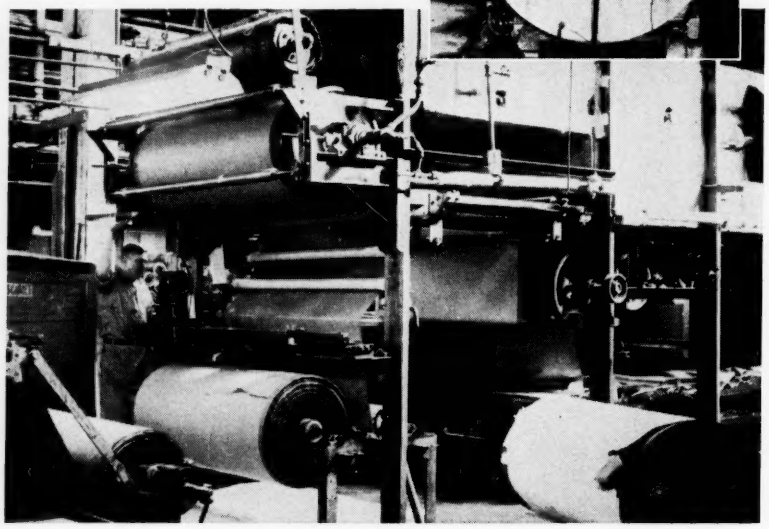

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For more information on Peak-Temp oil heaters, write to Cleaver-Brooks Company, Dept. L, 345 E. Keefe Ave., Milwaukee 12, Wisconsin.

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Chemicals

Activated Carbon.....is the most versatile liquid and gas purifier. All types of activated carbons are available. Details may be found in Bulletin J-103 which is offered.
158 *Barnebey-Cheney

Activated Carbons.....A new illustrated booket provides design data for planning both liquid and vapor phase continuous column adsorption systems.
139 *Pittsburgh Chemical Co.

Aliphatic Organics.....12-page catalog covers 150 different products with specifications and typical applications and gives chemical composition.
168A Armour Ind. Chem. Co.

Brightener....Calcofluor White brightener for treating packages. Emits eye-catching brilliance. Additional information on this product is available on request.
8-9a *American Cyanamid Co.

CoPolymer.....40-page data bulletin describes Gantrez An resin, a linear, polymeric anhydride available in several molecular weight ranges, with applications in many fields.
168B General Aniline & Film Corp.

Diallyl Phthalate Monomer.....How, when and why DAP can be used in polyester resin systems is discussed in bulletin 36 with tables and charts on properties and performance.
168C Food Mach. & Chem. Corp.

Dihdropyran.....is a colorless, mobile liquid of ether-like odor and is very reactive. Also exhibits properties of vinyl ether. Information in Bulletin 137.
57a *Quaker Oats Co.

Ethylene.....20-page booklet designed for developmental chemists and engineers using ethylene from cylinders covers major chemical reactions and gives extensive bibliography.
168D U. S. Industrial Chem. Co.

Filter Aid.....Celite ltration assures the right grade for every degree of clarity. Full details on how Celite gives the fastest, most efficient filtration.
95 *Johns-Manville

Filter Medium....Anthrafilt will give filter runs approximately twice as long as sand or quartz. Rates up to 200 mgd are obtainable with less clogging.
TR190 *Anthracite Equipment Corp.

Filteraids.....Bulletin B-14 descusses the principles and operating practices of filteraid filtration & its applications in many industries.
75 *Great Lakes Carbon Corp.

Hydrocarbon Resins...Anionic, cationic and non-ionic emulsions with high filler loading capacities are described in 12-page booklet that gives typical properties.
169A Pennsylvania Ind. Chem. Corp.

Hydrogen.....Technical data sheets describes Hydripills, a light weight, convenient, chemical source of hydrogen for industrial and laboratory applications.
169B Metal Hydrides, Inc.

Industrial Oil.....for trouble-free performance. Receives special refining to minimize emulsion problems and contains an additive to minimize foaming.
135 *American Oil Company

Insulating Foam.....Dimensional stability, reduced cost and lower density are the outstanding features of a new urethane insulating foam described in booklet.
169C Nopco Chemical Co.

Insulation.....A booklet on Dividend Engineering, a simple evaluation system for determining true economic insulation thickness is available on request.
169D *Owens-Corning Fiberglass Corp.

Light Absorbers.....Cyasorb light absorbers cause vinyl to resist discoloration and cracking under ultraviolet rays. Further information on this product is offered.
8-9c American Cyanamid Co.

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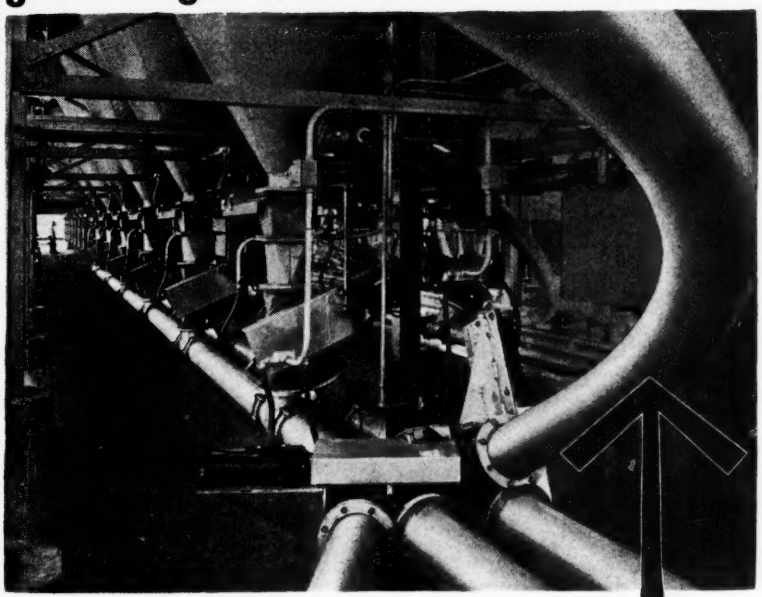

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☐ 34-10197 *Aluminum Pipe and Fittings*
☐ 34-10418 *Alcoa Unitrace: Combines Piping and Tracing in One Unit*
☐ 88-11251 *Cryogenic Applications of Alcoa Aluminum*
☐ 68-10460 *Process Industries Applications of Alcoa Aluminum*

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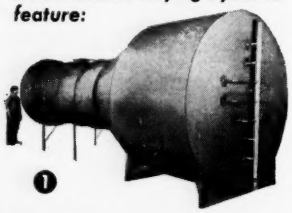

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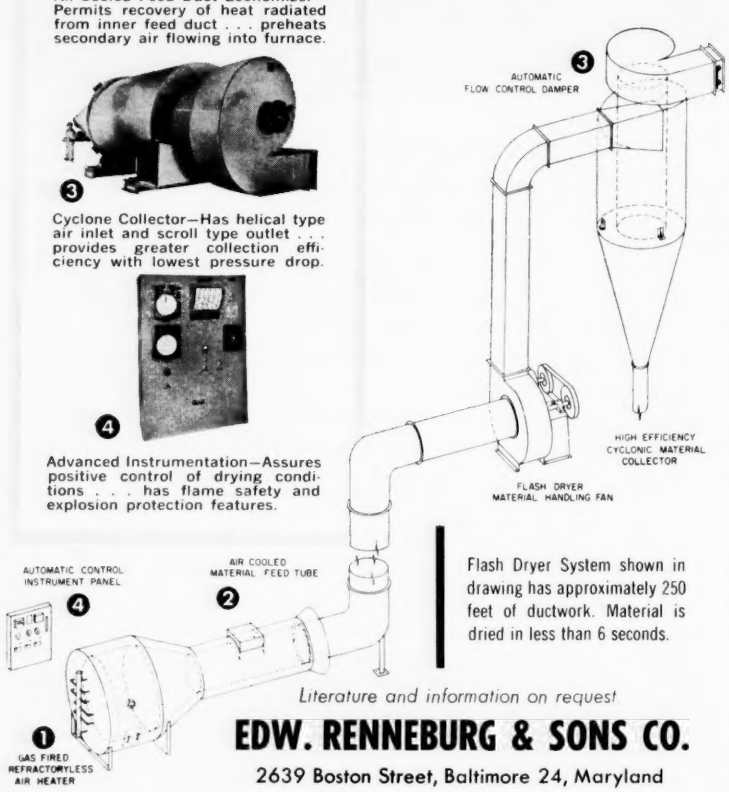

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Methylamines....64-page booklet contains review of all available technical data on the methylamines with discussions on shipping, handling, storage and safety.
170A Commercial Solvents Corp.

Methyltetrahydrofuran.....is a cyclic ether useful inorganic synthesis, and may also have value as a reaction solvent. Additional information in Bul. 136.
57-b *The Quaker Oats Co.

Monomer.....Data on triallyl cyanurate (TAC) should be helpful in research directed toward upgrading vinyl systems by increasing heat resistance & decreasing flow.
8-9d *American Cyanamid Co.

Phosphonol.....A low foam, alkali stable surfactant of high wetting and suspending power is described in 3-page data sheet that details specific applications.
170B Beacon Chemical Industries

Polyethylene.....Bulletin MB-10 discuses two formulations processable at fast production speeds with extruded film having exceptional toughness and clarity.
170C Eastman Chemical Products Inc.

Solid Lubricants.....Theory and use of solid lubricants is contained in brochure that discusses galling and seizing, high friction, chemical reactions etc.
170D Alpha-Molykote Corp.

Succinic Acid.....Technical bulletin I-11AR gives physical properties, suggested uses, and physiological properties of chemical uses as a general purpose food additive.
170E National Aniline Div.

Sulfamide.....is similar to urea in many of its reactions, except that it is more acidic, and can act as a dibasic acid. Further information & a sample is available.
53 *Allied Chemical, General Che. Div.

Textile Softeners.....16-page technical bulletin describes company's softeners and contains performance evaluation on the three products plus application suggestions.
170F Emery Industries Inc.

Toluene Diisocyanate.....Data sheet MS-108 escribes Nacconate 80 used in the manufacture of flexible and rigid urethane foams, elastomers and protective coatings.
170G National Aniline Div.

Trilay.....Technical bulletin describes a new noble metal campsite material with applications in the glass industry plus three articles on precious metals catalysts.
170H Engelhard Industries, Inc.

Construction Materials

Alloys.....Colmonoy alloys & methods can protect your equipment. The Spraywelder Catalog and the Colmonoy Hard-Surfacing Manual are available.
B179 *Wall Colmonoy Corp.

Aluminum.....A booklet entitled, "Process Industries Applications of Alcoa Aluminum" is available for information on the wide variety of applications of aluminum.
169d *Aluminum Co. of America

* From advertisement, this issue

Aluminum Alloys.....A booklet giving information on resistance of aluminum alloys to weathering & to chemically contaminated atmospheres is available.
171a *Aluminum Co. of America

Construction Material.....Fluoroflex is a specially processed Teflon construction material used for pipes, bellows & expansion joints, transfer hose, etc. Inform.
29 *Resistoflex Corp.

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73 *Flextallic Gasket Co.

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129 *The Ruberoid Co.

Nickel Steel.....9% Nickel Steel reduces cost of handling low-temperature liquids. The complete story on this steel, including details of "Operation Cryogenic".
10-11 *United States Steel Corp.

Nuclear Graphite.....No other material has so many useful nuclear properties. It is an excellent structural material, resists corrosion & is easily fabricated.
19 *The National Carbon Co.

Packings.....16-page catalog illustrates and describes complete line of pneumatic and hydraulic packings and includes data on conditions of operation, design application etc.
171A Chicago-Allis Mfg. Corp.

Protective Coating.....Properties and application techniques for Lyykold Fibrecoat, a weatherproof, mineral-armored asphalt, are described in 4-page bulletin.
171B American Bitumuls & Asphalt Co.

Stainless Steel.....Booklet "Producing Stainless Steels..Exclusively" is now available. It includes detailed sections on stainless steel plates, heads, etc.
33 *G. O. Carlson, Inc.

Wire Cloth.....Whatever metal or alloy needed in any size or quantity to the closest tolerances. High mesh counts are featured. A catalog is available.
37 *Cambridge Wire Cloth Co.

Electrical & Mechanical

Conduit Fittings.....New Mark 9 conduit is made from copper-free, corrosion-resistant aluminum in a wide range of types and sizes. Bulletin 2730 is offered.
46 *Crouse-Hinds

Couplings.....In addition to a simplified method of selecting a particular coupling, a 62-page catalog features a packer usage guide that lists 575 fluids and gases.
171C Snap-Tite, Inc.

Cushion Couplings.....Three types of flexible cushion couplings, designed to compensate for all kinds of shaft misalignment and absorb shock, vibration etc. described in bulletin.
171D Dodge Mfg. Corp.

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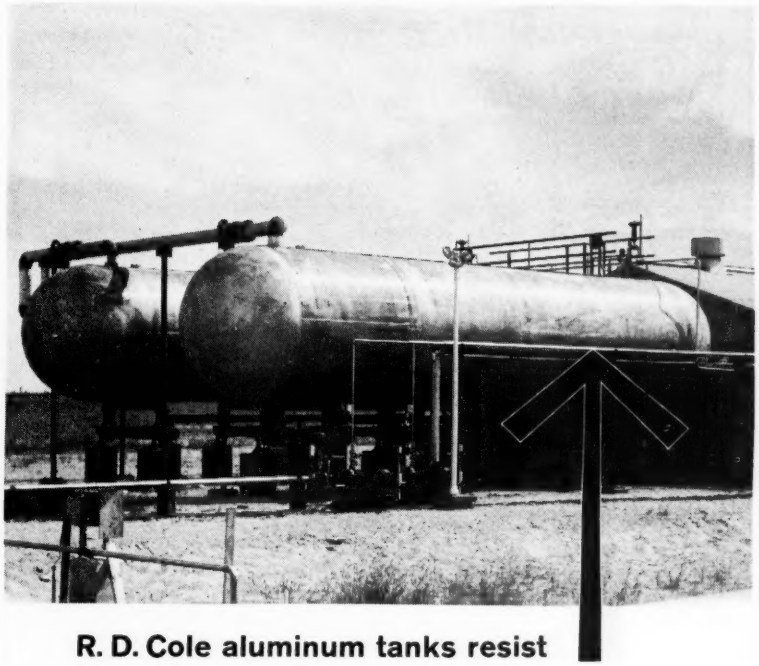

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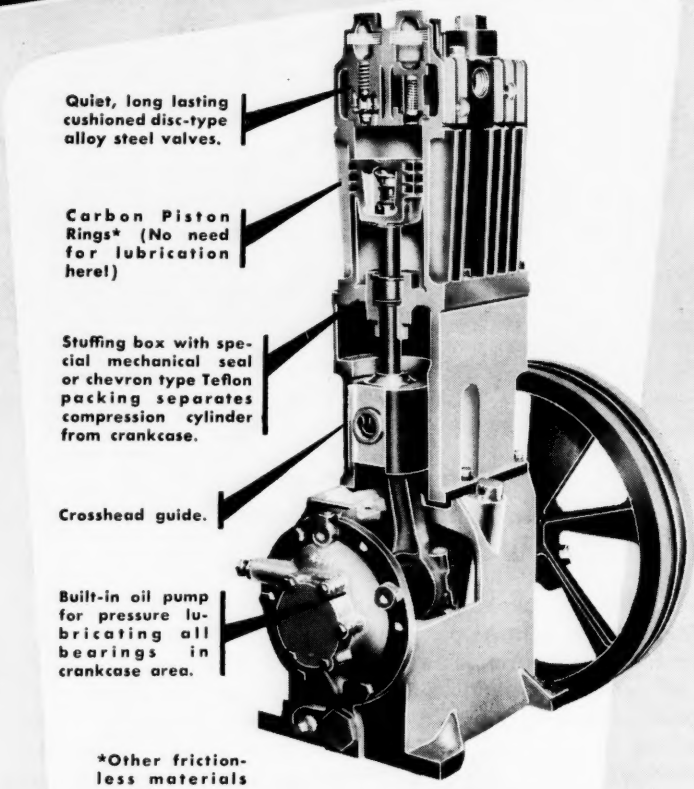
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Electrostatic Generators.....Features, applications, principles of operation and complete specifications for high voltage DC power supplies given in 8-page brochure.
172A Sames-USA

Gas Turbine.....Information on turbine-powered generator sets, and a complete line of gas turbine engines or industrial compressors is available.
26 *Solar Sub. of Internat. Harv.

Panel Boards, Explosion-Proof.....A 28-page fully illustrated catalog, Bulletin 661 is available for complete information on these explosion-proof panel boards.
1 *Appleton Electric Co.

Power Recovery Turbine.....designed for power recovery from any gas mixture. Further information on any power recovery turbine application is available.
Cov *Worthington Corp.

Reducers.....24-page catalog serves as a handbook on single reduction, right-angle spiral bevel gear speed reducers and contains specification tables, rating charts etc.
172B D. O. James Gear Mfg. Co.

Turbines, Solid-Wheel.....seldom see down time because of bonus reliability built into each turbine. Further details are contained in Bulletin S-116.
31 *Terry Steam Turbine Co.

V-Belt Drives.....Ready-reference manual of 112 pages contains technical data, drawings, weights, prices and selection tables for complete line of V-belt drives.
172C Dodge Mfg. Corp.

Handling & Packaging

Batching & Weighing.....New Batcheetron uses high-speed electronic methods to weigh & batch a number of liquids & solids by means of manual or punched card control.
77 *Fairbanks, Morse & Co.

Belt Conveyors.....Booklet contains result of a study to compose an accurate formula in determining horsepower requirements for belt conveyors plus other conveyor data.
172D Hewitt-Robbins

Lift Trucks.....Engineering, construction and operating features of seven lift trucks given in 24-page catalog that is sectionalized and keyed for easy reference.
172E Allis-Chalmers Mfg. Co.

Screw Conveyor Components.....A single component or complete systems—for standard or special requirements. Details are available on the complete line to match your need.
27 *Link-Belt Company

Skin-Packaging.....Explanation of skin packaging operation in 8-page booklet by brief case histories show the economy, adaptability and protection it affords.
172F Union Carbide Dev. Co.

Tank Unloader.....Rovalve High density tank unloaders speed production, cut operating costs and are easily installed. Details in Catalog Number 300.
172G W. G. Rovang & Associates

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Tanks.....Poxyglas tanks are 3 to 4 times as strong as conventional reinforced plastic tanks. Lighter than welded steel tanks. Corrosion-resistance chart is offered.
30 *Black, Sivalls & Bryson

Heating & Cooling

Boilers.....Bulletins describing Vogt boiler installations in a variety of industrial plants for power, processing and heating are available on request.
96 *Henry Vogt Machine Co.

Coolers.....Rotary Water Tube coolers give positive and effective cooling ahead of packaging, storing or further processing. Catalog "A" is available.
T178 *Davenport Machine & Foundry

Electric Heating Units.....in laboratory, pilot or production packages 7KW to 300KW. Liquid phase up to 700 deg. F. Further information is available.
R189a *American Hydrotherm Corp.

Heat Exchangers.....Helpful information on the design and fabrication of heat exchangers and pressure vessels is contained in Bulletins HE and CI which are offered.
4 *Downington Iron Works, Inc.

Heat Exchangers.....Brazed Aluminum surface consists of corrugated aluminum sheets brazed together to form a stack of layers that provide individual passages. Facts.
14-15 *Trane Co.

Heater Sections.....Heater sections for air-conditioning preheat, fresh air supply, and process and drying applications, with face-and-bypass damper systems described in bulletin.
173A L. J. Wing Mfg. Co.

Heating & Cooling Fins.....feature high ratio of surface area to face area and high air velocities without excessive friction or turbulence. Bulletin S-55.
153 *Aerofin Corp.

Oil Heaters.....Peak-Temp oil heaters provide constant heat so vital in processing. Heat transfer oils are used instead of steam to heat faster. Information.
164 *Cleaver-Brooks Co.

Oil & Gas Fired Heating Units..... with optimum temperature control. Packaged for indoor or outdoor use. Complete information on these units may be had upon request.
R189b *American Hydrotherm Corp.

Steam Generators.....for steam requirements for heating, air conditioning, autoclaving and processing. A new booklet is offered for details on these generators.
93 *Clayton Manufacturing Co.

Temperature Control.....A complete line of pressure and temperature regulators is available. Detailed information on control applications is contained in Bulletin IV 1014.
148 *Spence Engineering Co., Inc.

Thermal Fluids.....Systems operating with Thermal Fluids deliver process heat up to 600F. from unpressurized liquid. Technical Bul. 1248 is available.
147 *Monsanto Chemical Co.

* From advertisement, this issue

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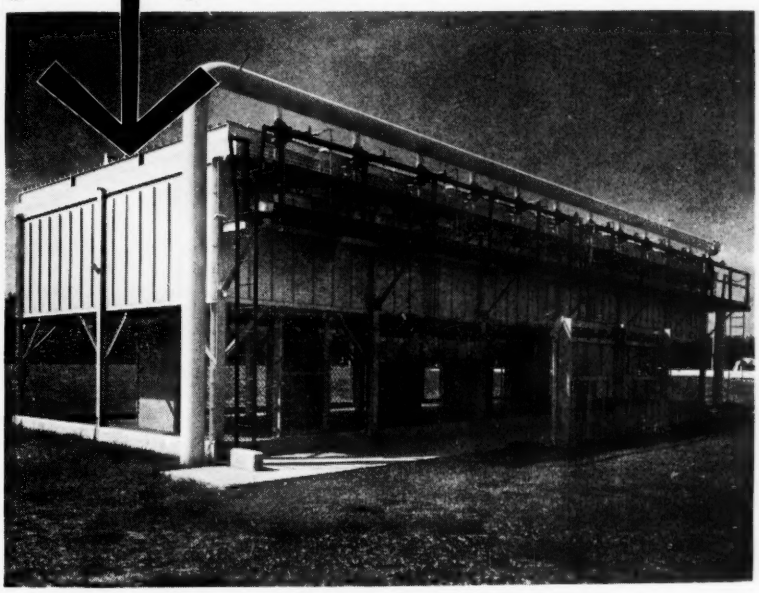

Griscom-Russell heat exchanger has aluminum fins for improved gas engine cooling system

This fin-fan heat exchanger cools gas engine jacket water at the Paris, Tenn., plant of American Louisiana Pipeline Co. Similar units are installed at the Shelbyville, Ind., and Greenville, Miss., plants, all designed and built by Griscom-Russell Co., Massillon, Ohio. Cooling fins, of special G-R design, are made of Alcoa® Aluminum. High thermal conductivity combined with natural resistance to corrosion, ease of fabrication and low first cost made aluminum the logical choice of material. Perhaps Alcoa Aluminum can improve your good design. For more information, please send the coupon.

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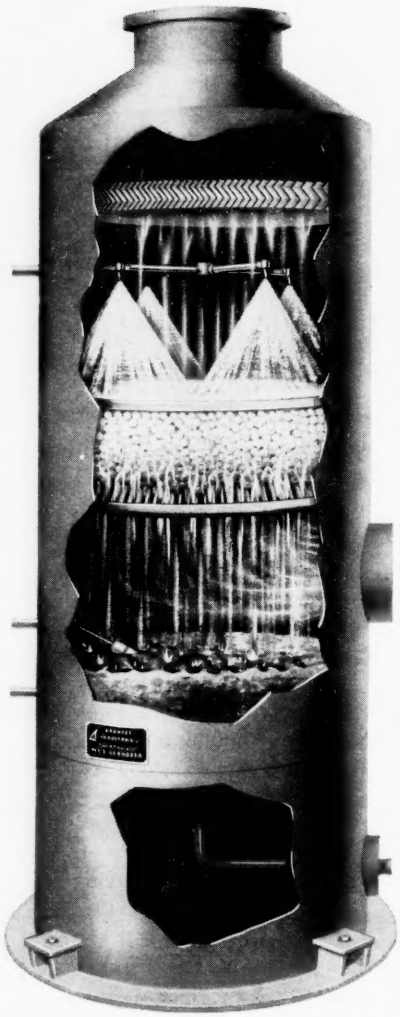

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LITERATURE . . .

Instruments & Controls

Control.....12-page technical manual TM-8 on "Generalized Control Theory" explains with text and examples the basic theories in automatic fluid control.
174A Fisher Governor Co.

Data Processing System.....The new Monorbot XI is a complete system. It is no larger than a desk & requires no special flooring or air conditioning. Inform.
51 *Monroe Calculating Machine Co.

Distillation.....Bulletin 91-45-01 outlines typical practices for control of distillation column and contains illustrations of pertinent instrument loops.
174B Fischer & Porter Co.

Electronic Controls.....M-line offers the widest scope of compatability in operation with unmatched interchangeability of components. Details are offered.
71. *Leeds & Northrup

Liquid Density Gauges.....New series of gauges providing continuous measurement of solution/slurry density without contacting material or moving parts is described in bulletin.
174C Nuclear-Chicago Corp.

Meter-Relays.....Bulletin No. 5 details story of locking contact meter-relays and gives standard circuits for achieving most popular types of control action.
174D Assembly Products Inc.

Meters.....guard your liquid inventories and control the flow of industrial liquids. You'll have accurate records of costs plus other advantages.
141 *Rockwell Mfg. Co.

Mixture Control.....Performance report describes application of an engine mixture control system to save fuel costs and reduce engine maintenance charges.
174E Bailey Meter Co.

Pneumatic Transmitters.....give you a true primary and transmitted signal for indication or control. Factful Bulletins 360 and 361 can help in your selection.
84 *Manning, Maxwell & Moore, Inc.

Pocket Computer.....The Evapo-Rater helps calculate the evaporation rate of a hydrocarbon solvent in minutes and can be used right at your desk.
69 *Shell Oil Co.

Thermocouples.....Catalog on thermocouple wire, extension wire and multipair extension cable gives information on insulation, sizes and prices of over 150 standard items.
174F Claud S. Gordon Co.

Thermometers.....Bi-Metal thermometers make accurate temperature readings sharp and sure at all check points. Further information is found in Catalog 155.
34 *Manning, Maxwell & Moore

Thermowells.....Catalog lists all standard type thermowells for test instruments and provides detailed dimensional information on, and materials available in each type.
174G Trinity Equipment Corp.

* From advertisement, this issue

Pipe, Fittings & Valves

Aluminum Pipe & Fittings.....A booklet describing aluminum pipe and fittings and their varied applications and dimensions is available on request.
169a *Aluminum Co. of America

Ball Valve.....Flo-Ball offers top entry, in-line maintenance, top & bottom guided ball, double seats, flanges integral with body and other features.
87-88 *Hydromatics, Inc.

Ball Valves.....Bulletin PB911 describes valve in which ball is rotated by an eccentric cam to eliminate sliding friction and permit use of hard metal seating surfaces.
175A General Kinetics Corp.

Ball Valves.....Catalog 1200-A provides detailed information on line of manually operated and pneumatically operated ball valves ranging from ¼" to 12".
175B Hills-McCanna Co.

Connectors.....A general catalog describing the line of pressure vessel connections available in detail may be had upon request to help solve problems.
T177 *Lenape Hydraulic Press. & Forg.

Control Valve.....The new Series 1400 low flow control valve is available in a full range of materials, ratings and sizes. Complete details are in Bulletin B803-1.
127 *Minneapolis-Honeywell

Control Valves.....8-page catalog covers complete line from ¼" to 6" sizes in various metals and includes data on pressure and temperature ratings, capacities, dimensions etc.
175C OPW-Jordan

Expansion Fitting.....Bulletin describes expansion fitting as a time saving, reliable assembly procedure and includes coefficients tables and rate calculation tables.
175D Cincinnati Sub-Zero Prod.

Expansion Joints.....Catalog 56 contains complete & comprehensive engineering data for Expansion Joints from 3" to 50' diam., pressures to 3600 psi, temp. to 1600F.
151 *Zallea Brothers

Gate Valve.....Bulletin 302 describes and illustrates rubber seated gate valve and lists materials, dimensions, actuators and outlines broad areas of use.
175E DeZurik Corp.

Globe Valves.....feature less corrosion attack because of elimination of cavity between stem and disc. Full information is to be found in Bulletin #7 which is available.
162 *Alloy Steel Products Co.

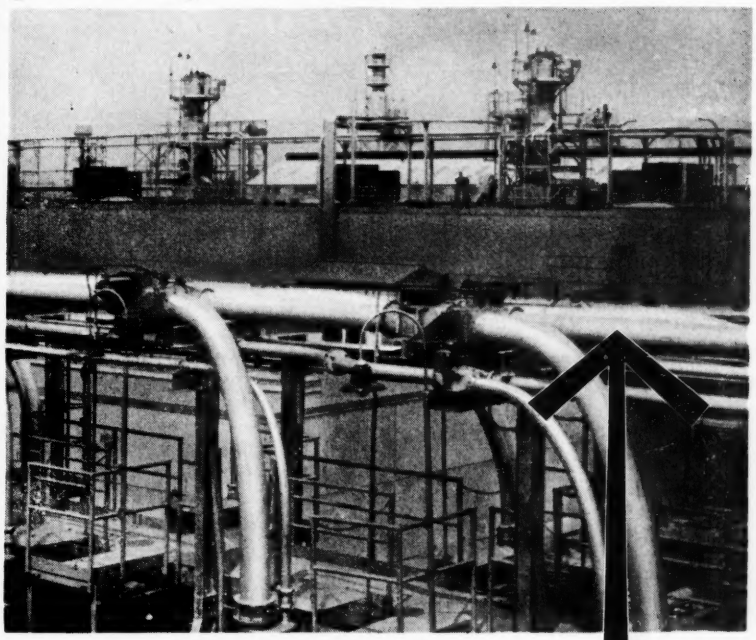
Heat Exchanger Tube.....Titanium heat exchanger tube with .049 wall thickness and less can successfully handle products such as acetic acid, nitric acid and chlorine.
17-18
*Wolverine Tube Div. of Calumet Hecla

Metal Hose.....Abrasion resistant metal hose designed for conveyance of bulk materials where resistance to severe abrasion and corrosion is required is described in bulletin IPB3Aa.
175F Universal Metal Hose Co.

* From advertisement, this issue

from ALCOA

good designs made better with aluminum



Dracco Conveyor ensures contamination-free handling of polyolefins

Polyolefins, having stringent specifications for purity, require a special type of bulk handling. That's why this network of Dracco's Airstream Conveyor Systems incorporates miles of ALCOA® Aluminum piping. It's a multiphase system designed by Fuller Company's Dracco Division for Phillips Chemical Co., leading producer of high-density polyolefins. Aluminum piping protects product purity, avoids unwanted color. With aluminum, there's no maintenance inside or out; superior heat-transfer ability cools conveying gases. Perhaps aluminum can improve your good design. For more information, please send the coupon.

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ALUMINUM COMPANY OF AMERICA

Aluminum Company of America, 825-Q Alcoa Building, Pittsburgh 19, Pa.
Please send me the following literature covering Alcoa Aluminum for tubular products and other uses in the process industries.

☐ 34-10197 Aluminum Pipe and Fittings
☐ 34-10418 Alcoa Unitrace: Combines Piping and Tracing in One Unit
☐ 68-10460 Process Industries Applications of Alcoa Aluminum

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Chemical / Electrical / Mechanical

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Responsibilities include engineering, process design, equipment specification and evaluation, field check-out of cryogenic liquid and gas plants. Up to 15% travel required.

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Makes engineering calculations and designs complex piping systems required for cryogenic liquid and gas plants.

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Layout calculations and design of industrial buildings to house process electrical and control equipment for industrial liquid and gas plants.

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LITERATURE . . .

Nozzles.....Turret nozzles fight fires from any angle. Every type is designed to fight fire four ways: with solid FOAM, FogFOAM, WaterFOG and solid water stream. Bklt.
32 *Rockwood Sprinkler Co.

Pipe.....Bondstrand plastic pipe is made of tension-wound glass filaments impregnated with resin. Complete information is available in bulletin on physical & design data.
145 *Amercoat Corp.

Pipe & Fittings.....The exact same alloys can be furnished in fittings & flanges as well as pipe. Further information is to be found in Bulletin FB78.
38 *Babcock & Wilcox Co.

Piping & Tracing.....A bulletin describing Unitrace which combines piping and tracing in one unit is offered and may be had upon request.
169b *Aluminum Co. of America

Spray Nozzles.....A complete selection of automatic pneumatic spray nozzles for use where controlled intermittent spraying is required. Bulletins 114 & 116.
T179 Spraying Systems Co.

Vacuum Valves.....Details on high vacuum valves designed to serve as master control in high vacuum systems using diffusion and mechanical pumps given in 8-page booklet.
176A Cenco Instruments Corp.

Valves.....Eccentric-Action, Non-Lubricated valves mean no more leakage-losses and no more greasing or oiling. Details are contained in Control Bulletin 150.
43 *DeZurik Corp.

Valves.....Chemical Porcelain valves practically never need maintenance or replacement. Y-Valves & Angle Valves, in ½" to 6" sizes. Also safety valves, etc. Cat. 567.
146 *Lapp Insulator Co., Inc.

Valves.....Flocontrol valves assure positive pinpoint control—eliminate all guesswork. These valves are available in bronze & steel to meet the most demanding services.
63 *Manning, Maxwell & Moore

Valves, Gate.....Aluminum gate valves feature high-corrosion-resistance and double disc parallel seat principle. Wedge design reduces friction.
28 *Darling Valve & Mfg. Co.

Valves, Stainless Steel.....All the features of these valves are covered in the Stainless Steel Catalog No. 59SS which is available on request.
131 *Jenkins Bros.

Process Equipment

Blending System.....4-page data sheet describes digital and analog blending system that can handle flow rates from 1/10 to 25,000 gpm with blend accuracy of ±1/10 of 1%.
176B Potter Aeronautical Corp.

Centrifugal Contactor.....Brochure P-100 describes line of countercurrent, liquid-liquid and vapor-liquid machines and includes flow diagrams and installation photos.
176c Podbielniak, Inc.

* From advertisement, this issue

Centrifugal Separator.....assembled as a package unit. To process slurries difficult to dewater. Details are contained in Brochure 961 which is available.
B178 *Heyl & Patterson, Inc.

Clarifier.....Bulletin describes new water-jet-propelled clarifier for the reduction of turbidity, color, suspended matter etc. and contains schematic drawing.
177A The Permutit Co.

Conditioner.....Verticone conditioner with jet spray coats or impregnates particles, granules or powders without degradation. Information is available.
79 *Johnson-March Corp.

Continuous Muller.....Multi-Mull offers economy, control, speed, quality, and boosts production with a decrease of equipment & floor space requirements. Details.
12-13 *National Engineering Co.

Dryers.....Oriad Desiccant dryers offer complete reactivation, perfect temperature control, and full automatic operation. Further details in Bulletin D-103.
94 *The C. M. Kemp Mfg. Co.

Drying Systems.....Instantaneous Drying Systems process fine wood fibers, filter cakes, sewage sludge and other types of particulate solids. Literature
170 *Edw. Renneburg & Sons Co.

Dust Arresters.....Automatic dust arresters operate continuously without even momentary loss of efficiency. Complete information on any type problem is offered.
42 *Buell Engineering Co., Inc.

Evaporators.....Characteristics, suitability for various liquids and end products, and operation of line of evaporators and crystallizers are described in catalog 393.
177B Blaw-Knox Co.

Liquids-Solids Separation.....Eight types of centrifugals and filters to separate solids from liquids. Research & Development Center for pilot-scale testing.
2 *Bird Machine Company

Mill.....Vibro-Energy mill wet-grinds particles from 60 mesh to one micron or smaller. An illustrated technical paper is available for further details.
125 *Southewestern Engrg. Co.

Mill.....Pulver-Mill does in one step what used to take two. Designed for fine grinding and precise end product classification. Bulletin 093.
189 *Sturtevant Mill Co.

Mixers.....Lightnin mixers cut downtime in three places at once. They offer shaft seal assemblies and come all assembled in one package, aligned & ready to install.
192 *Mixing Equipment Co.

Mixers.....A full line of side drive, tank top, portable or tripod and continuous pipeline mixers for your mixing needs. Additional information in Bulletin 582.
65 *Nettco Corporation

Pulverizer.....Pulvocron will reduce the particle size of your material to specifications in one, quick operation. Further information may be had upon request.
152 *The Strong Scott Mfg. Co.

* From advertisement, this issue

High strength steel connections — contour forged and machined to exacting measurements — built to last under extreme pressures — these are the requirements of America's modern aircraft carriers. In anticipation of the ever-changing needs and new applications of military and industry, Lenape constantly searches for improved pressure vessel connection designs of all types.
Write today for Catalog describing the complete Lenape Line.

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LENAPE HYDRAULIC PRESSING & FORGING CO.
DEPT. 109 WEST CHESTER, PENNSYLVANIA

THE BIGGER, THE BETTER . . . as shown by the equipment above, being readied for shipment.

FIBERGLASS GIANT . . . READY TO GO!

Reinforced plastic equipment is worthy of intensive study as the modern way to approach a wide variety of chemical storing, processing, and conveying problems. When a customer comes to JUSTIN, his particular application receives consideration from every angle — DESIGN, MATERIAL, WORKMANSHIP — and TOP QUALITY is the result.

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Write for Bulletin J-1-62
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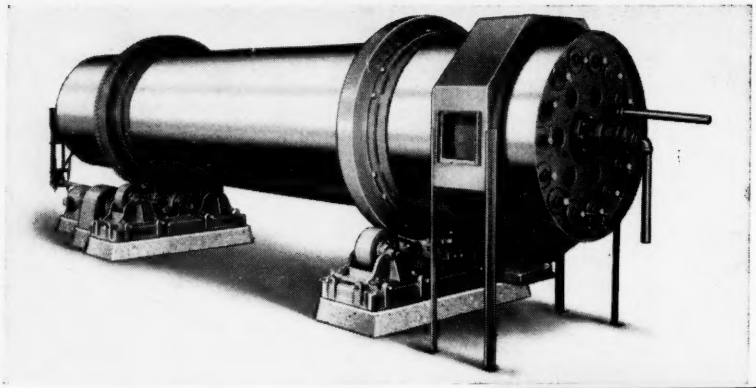

"DAVENPORT" ROTARY WATER TUBE COOLER

Continuous, positive and efficient cooling ahead of packaging, storing or further processing. "Davenport" Water Tube Coolers are the only coolers which have a closed water circulating system. Investigate our exclusive tube design—best in cooling performance.

Let our engineers consult with you on your Pressing, Drying and Cooling problems or send for our catalog A. For quick reference consult your Chemical Engineering Catalog.

DAVENPORT MACHINE AND Foundry Company
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DAVENPORT

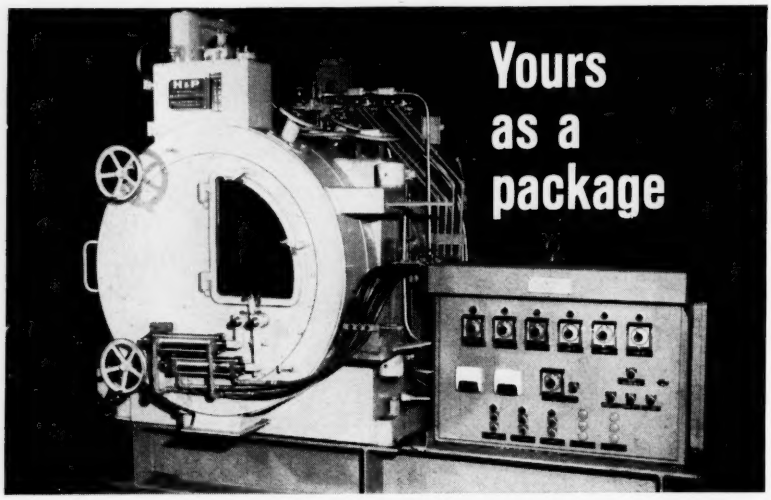
PRESSING — DRYING and COOLING Equipment

Continuous DeWatering Presses

ROTARY DRYERS
Steam Tube, Hot Air and Direct Fire

Atmospheric DRUM DRYERS

ROTARY COOLERS
Water and Air



This Horizontal Reineveld Centrifugal Separator was assembled for completely automatic processing of chemical slurries difficult to dewater.

The intricate electrical and pneumatic controls have been applied specifically for this duty, with Heyl & Patterson assuming complete responsibility for flawless operation.

You, too, can avail yourself of H & P's experience and obtain a complete "package" developed for optimum performance. Write for brochure 961 or request a visit.

H&P

HEYL & PATTERSON, inc.

55 FORT PITT BLVD., PITTSBURGH 22, PA., COurt 1-0750

LITERATURE . . .

Reinforced Plastic Equipment.....for your particular application. The solution to a wide variety of chemical storing, processing & conveying problems. Bul. J-1-62.
B177 *Justin Enterprises, Inc.

Solids Processor.....adds vacuum drying to liquids-solids blending. Systems completely packaged. In standardized models with charge capacities from 1 to 50 cu. ft.
48-49a *Patterson-Kelley

Wet Scrubbers.....Aeromix wet scrubbers have no pumps, nozzles or filters to clog. Units are now operating in Chemical, Coal, Fertilizers, Rock Products & other fields.
174 *Aerotec Industries, Inc.

Pumps, Fans & Compressors

Acid Pump, Steam Jacketed.....guarantees trouble-free, low cost pumping of solutions which thicken or solidify above ambient temperatures. Details are available.
191 *A. R. Wilfley & Sons, Inc.

Centrifugal Compressor.....Model HTP has capacities to 5,000 cfm to meet the stiff demands of modern refinery, chemical, petrochemical & nuclear plants. Bul. SSC-161.
137 *Roots-Connersville Blower Div.

Centrifugal Compressors.....for numerous applications which require gas compression, air compression, low temperature refrigeration, vacuum & other services.
81 *Clark Bros. Co.

Centrifugal Pumps.....bulletin 105C illustrates and describes complete line of single-stage, double suction, horizontal split case pumps with capacity range to 6000 gpm.
178A Aurora Pump Div.

Compressors.....to handle heavy load in low-temperature processing. A complete line of compressors to assure peak performance for your compression or power facilities.
133 *Cooper-Bessemer

Compressors.....“Dry Cylinder” compressors protect your product by complete separation of cylinder and crankcase. Information in Bulletins VE-100 & VE-102.
172 *Corken's Inc.

Compressors, Rotary.....have no reciprocating parts, no valves, no metal-to-metal contact in the compression chamber resulting in minimum downtime expense.
20-21 *Fairbanks, Morse & Co.

Pumps.....for applications where pressures are high and liquids are hard to handle. Complete data on the line of pumps are available on request.
89 *Aldrich Pump Company

Pumps.....Engineering manual contains valuable data for pump requirements including formulae, viscosities, materials recommended, friction and conversion units.
178B Marlow Pumps

Pumps.....Jet pumps are available in a broad selection of models, standard or special, steam, air or liquid operated in a variety of materials. Information.
157 *Penberthy Mfg. Co.

* From advertisement, this issue

Pump, Vacuum.....The new Series H Microvac pump is designed for compactness. Information about this type plus a Vacuum Slide Calculator are offered.
L190 *F. J. Stokes Corp

Services & Miscellaneous

Air-Powered Equipment.....32-page catalog discusses use of pneumatics in materials dispensing equipment and describes compressors, pumps, dispensing valves and systems etc.
179A Lincoln Engineering Co.

Cleaners.....Specialized cleaners available for any cleaning problem. For towers, tanks, pumps, compressors, exchangers, lines, etc. Literature & details.
155 *Oakite Products, Inc.

Incineration & Disposal.....A new Bulletin No. 119 covers an expanded line of waste incineration & disposal systems and may be had upon request.
179B *Thermal Res. & Engrg. Corp.

Industrial Sockets.....are built in a wide range of sizes with a full range of extensions and handles. A new 180-page industrial catalog is available.
154 *Snap-On Tools

Marketing System.....New Mark-Trol eliminates 95% of the mess & maintenance of round chart recorder inking systems. Literature is offered for further details.
67 *The Esterbrook Pen Co.

Pelletizing Process.....Information on the Spherodizer process for pelletizing slurries & concentration solutions is contained in a new brochure.
39 *The Chemical & Industrial Corp.

Professional Advancement....."New-Product Development Vital to Industry" booklet outlines control methods necesasry to insure ideas reaching a profitable marketing stage.
179C Western Supply Co.

Roofing Manual.....A quick, clear answer to almost any roofing question may be found in the 36-page Roof-Manual which may be had upon request. Many subjects covered.
156 *Lion Oil Company

Silicone Insulated Equipment.....For information on the advantages of silicone insulated equipment, see the brochure, "Specify Silicone Insulated Equipment & Save."
61 *Dow Corning Corp.

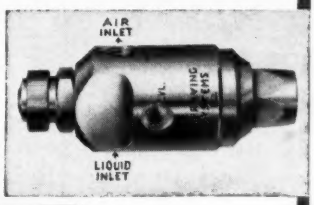
Skylights.....Wasco Twin Dome skylights are completely sealed, insulated and shatterproof. Inner & outer domes available in any combination. Information.
8-9b *American Cyanamid Co.

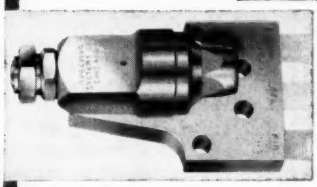
Tank Safety.....Safety guide SG-10 details recommended safe practices and procedures for entering tank and other enclosed spaces and includes sample work permit form.
179D Manufacturing Chem. Assn.

Testing Sieves.....48-page handbook carries complete specification on the U. S. Sieve Series ASTM E-11-61 and contains useful information on sieve selection.
179E W. S. Tyler Co.

* From advertisement, this issue

pneumatic atomizing
SPRAY NOZZLES





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AUTOMATION

Spraying Systems offers a complete selection of automatic pneumatic atomizing nozzles for use where controlled intermittent spraying is required. In-built shut-off valve is air operated. Precision built for exact control of spray type and volume. Compact and easily installed. Write for Bulletins 114 and 116.

SPRAYING SYSTEMS CO. 3275 Randolph St. • Bellwood, Ill.

FOR EASIER SPRAY NOZZLE INSTALLATION in any type of system . . . see Catalog 24 for Spraying Systems Adjustable Joints . . . and Bulletin 93 for the NEW Spraying Systems Split-Eyelet Connectors.

Mild Steel Outlasts Stainless!

The Colmonoy Spraywelder applies powdered nickel-base alloys smoothly and quickly. Overlays are then fused and ground.

Left: mild steel sleeve with Colmonoy No. 6 overlay after 395 days service. Right: stainless steel (316) sleeve after only 105 days service.

COLMONOY HARD SURFACING CUTS PUMP SLEEVE WEAR

Much longer wear and fewer packing changes are the results reported in using Colmonoy hard-surfaced mild steel pump sleeves in a Desalta charge pump where stainless steel sleeves were used before. Maintenance costs are now considerably lower. Compare the two pump sleeves in photo.

Colmonoy alloys and methods can protect your equipment, save you money. Write for the Spraywelder Catalog and the Colmonoy Hard-Surfacing Manual today.

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▶ **Undisplayed Rates**—$2.10 per line, 3 lines minimum. To figure advance payment count 5 average words as a line; box number counts as 1 line. 10% discount if full payment is made in advance for 4 consecutive insertions. Not subject to agency commission.

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Major eastern electronic manufacturer is seeking industrial representation for its line of pressure switches and transducers. Potential sales in the food processing, instruments and controls, petroleum and chemical, water and sewerage industries. Please write full particulars to RW-7682, Chemical Engineering.

SELLING OPPORTUNITY WANTED

Wanted — Manufacturer's Rep., located in Cincinnati; desires lines for chemical, paint, food, and beverage industry. Reply RA-7607, Chemical Engineering.

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put the solution of your problems up to a specialized Consultant. His broad experience may save you months of costly experimentation.

TEXTILE TECHNICAL DEVELOPMENT AND LIAISON OFFICER
FOR JAPAN

The International Wool Secretariat invites applications for the post of Technical Officer in its Japanese Branch, Tokyo.

The International Wool Secretariat is an organization established by the statutory Wool Boards of Australia, New Zealand and South Africa for carrying out their global policy of increasing the consumption of wool by means of promotion, market research, scientific research, technical development and liaison with all segments of the wool consuming and distributing industries.

Applicants should have a degree in chemistry, physics, chemical or mechanical engineering or the equivalent as well as several years experience in either research, development or production in the textile industry. Such experience in the various branches of the wool textile industry would be an advantage.

Fluency in speaking Japanese and reading Japanese professional publications is essential. The duties of the Technical Officer will include organizing a technical information and service group to introduce into the Japanese wool textile industry new techniques (chemical and physical) for producing new and improved wool products and for increasing the efficiency of wool manufacturing. The Technical Officer will be required to maintain close contact in English with similar I.W.S. operating groups throughout the world.

Remuneration will compare favorably with similar appointments in Japan.

Applicants should apply in writing giving full details of their qualifications and personal background to:

Director of Science and Technology
The Wool Bureau, Inc.
360 Lexington Avenue, New York 17, N. Y.

WANTED
Electrical, Mechanical or Chemical Engineering Graduates

. . . to be trained as Sales Engineers for Cleveland, New York, Chicago, and Richmond, Virginia. We also have an opening for man with technical background for inside office work at Los Angeles. Prefer men between 25 and 32 years of age who have had industrial process experience. Successful applicants will be given a three-month factory course starting February 1, 1962.

Write Harry E. Beane, Vice President
THE BRISTOL COMPANY
Waterbury 20, Connecticut

Maintenance Engineer

Pennsalt Chemicals Corporation has opening for experienced Maintenance Engineer. Must be graduate engineer, either mechanical or chemical with at least 5 years chemical plant maintenance experience. Please submit resume of education, experience, and salary expected.

Personnel Administrator
PENNSALT CHEMICALS CORPORATION
Wyandotte, Michigan

EMPLOYMENT OPPORTUNITIES

(Continued from opposite page)

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San Francisco

Bechtel Corporation offers immediate employment opportunities to chemical engineers experienced in process design of major petrochemical, refinery, or similar processing units.

Liberal transportation and relocation allowances for you and your family. Please send resume of experience, including present and required salary, to W. A. Anderson, Technical Recruiting.

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CARIBBEAN AREA

Desired for opportunities in a large modern refinery of the Lago Oil & Transport Company, Ltd., in Aruba, Netherlands Antilles, an affiliate of STANDARD OIL COMPANY (N.J.). Candidates must be graduate Chemical Engineers with 3 to 5 years refinery experience and a working knowledge of refinery processes for performance analysis, design and economy evaluation of the operation of a major refinery. Possibilities for later assignment to Economics and Programming Group. Liberal employee benefits including home vacations with travel allowances. Interviews will be arranged for qualified candidates. All replies confidential. Send complete resume of work experience and personal data to:

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Department E
Radio City Station
New York 19, New York

CHEMICAL ENGINEERS

Our Technical Department is looking for Chemical Engineers to do project engineering in process development. We prefer a minimum of five years experience, not necessarily confined to our type operation. These are good opportunities with a steadily growing company. Salary commensurate with experience and ability.

Our plant is located in Southeastern North Carolina near several beaches and other recreational facilities.

Write in full to

Personnel Department
Riegel Paper Corporation
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Acme, North Carolina

SALESMEN WANTED

For major supplier of ceramic materials. Must have basic knowledge of inorganic chemistry and record of successful selling experience. Should be around 35, willing and able to travel. One territory on west coast, one in mid west.

SW 7631, Chemical Engineering
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

Equipment Searchlight

CE's Searchlight spots the big bargains in used, resale and rented equipment. Check this issue's listings—most complete in the field—for items you need now.

▶ **Coverage** — National. Equipment and facilities—used, resale and rental—for the process industries. For sale, wanted, for rent.

▶ **Rates**—$21.75 per inch for all ads except on a contract basis; contract rates on request. An advertising inch is measured ⅞ in. vertically on a column; 3 columns, 30 in. per page. Ads acceptable only in display style.

▶ **Closing Date**—November 27th issue closes November 3rd. Send all new ads to Chemical Engineering, Classified Adv. Division, P. O. Box 12, New York 36, N. Y.

SPECIALS

Kettles: 275 gal. type 316 st. steel, agitated.
Mill: Day Hispeed Model B 14x30" 3-Roll.
2-roll Mill: Stewart Bolling 6" x 11", 5 hp.
Pebble Mills: Abbe #3, #6, and others.
Dryer: American 24x48" dbl. drum.
Dryer: Bowen lab. spray, st. st.
Evaporator: Buflovak, sgl. eff, st. st. 94 sq. ft.
Dryer: Porter 2 x 4' vac. drum., st. st.
Centrifugal: Tolhurst 26" rubber 2-speed.
Filter: Sweetland #5 st. st. lined.
Filter: Oliver precoat 12x2" type 316 st. st.
Vacuum Pans: 42" and 72" stain. steel.
Dryer: Proctor & Schwartz 6-tray st. st.
Powder Mixers: Day Jumbo 120 cu. ft.

Write us or call Seeley 8-1431
Send us a list of your idle machines

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No better values at any price

72 CFM 1500 PSI 6½-3¾-1⅝x7 CP
80 CFM 3500 PSI 6¾-4-1 7/16x9 IR ES3
138 CFM 100 PSI 7x7, Ing. ES. CP & Joy
208 CFM 350 PSI 9-4x9 Ing., ES2
288 CFM 100 PSI 9x9 Ing. Worth, CP
306 CFM 100 PSI 9x7 Joy WG9
311 CFM 1500 PSI 10½x7⅛-3⅛-13 IR-ES3
465 CFM 100 PSI 12x11-IR-ES CP.T. Worth HB
502 CFM 125 PSI 12x13 Worth HB
676 CFM 110 PSI 15-9¼x12 Ing. XRE 3-60-220
686 CFM 100 PSI 14x13 Ing. ES
880 CFM 125 PSI 18-11x10 Ch. Pn. v-ce 150 HP Syn 3-60-440/2300
1065 CFM 110 PSI 18-12x14 Ing. Rand XRE 175 HP Syn 3-60-440
2200 CFM 100 PSI 26-15x28 Ch. Pn. oce 350-HP 3-6-4160 .8 PF
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AIR COMPRESSOR

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BLOWERS

7600 CFM, 12 PSI, 500 HP drive, new 1951, very good condition . . . Price $3950 each.

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Pfaudler 10 gal. Glass Lined Kettle
Hersey 5'x26' Rotary S.S. Dryer
Buffalo 32"x90" Double Drum Dryer
Day Hy-R Speed Mill 20 HP XP
SEND FOR LISTINGS
STEIN EQUIPMENT CO.
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IT'S GOT TO GO . . . BEFORE IT SNOWS!

LIQUIDATING TWO CHEMICAL PLANTS
NIAGARA FALLS, N. Y. and EVERETT, MASS.

COLUMNS

78″x18′x¼″—316 Stainless Steel, 14 trays 180 bubble caps per tray, 50 PSI.
72″x30′x⅛″—347 Stainless Steel, 21 trays 38 bubble caps per tray.
48″x41′x5/16″—316 Stainless Steel, 40 trays, 70 bubble caps per tray, 100 PSI design.
36″x20′x3/16″ packed 316 Stainless Steel, 100 PSI.
14″x17′6″x⅛″ packed 316 Stainless Steel.
12″x18′8″x3/16″ packed 347 Stainless Steel, 100 PSI.
Pfaudler 20″x27′, **16″x21′, 16″x10′** glass lined.

REACTORS

Pfaudler 500 gal. and 300 gal. glass lined, jacketed, agitated, 75 PSI.
Dopp 1700 and 1000 gal. Ni-resist, jacketed, Type "J" agitator, 150 PSI.
Patterson 500 gal. Steel, jacketed, agitated, 50 PSI.
Alloy Tank 750 gal. Type 316 Stainless Steel, 42 PSI.
Alloy Tank 300 gal. Type 316 Stainless Steel, 42 PSI.

COMPRESSORS—VACUUM PUMPS

Clark 9920 CFM 149PSIA Suction, 239PSIA Disch.
Allis-Chalmers Centrif. 7500CFM @ 42.5PSI; 1250 HP.
Worthington YO 1360 CFM @ 35 PSI; 150 HP.
Worthington 1015 CFM @ 35 PSI Steam Driven.
Norwalk Hydrogen Compressor 5 CFM @15000 PSI.
Nash L3 Stainless Compressor 127 CFM @ 20 PSI.
Nash CD 663 Stainless Compressor 50 CFM @ 75 PSI.
Nash #4 and TS10 Vacuum Pumps.
Stokes 612F Microvac 500 CFM Vacuum Pump.

CENTRIFUGES—FILTERS

Sharples C-27 Stainless Super-D-Hydrator.
Fletcher 40″ Suspended Perforated basket 15/7½ HP.
Rochester 30″ Stainless Suspended imperforate basket.
Sharples #6 Super Centrifuge, Stainless bowl.
Oliver 5′3″x3′ Stainless Precoat Rotary Vacuum Filter.
Goslin 36″x24″ Stainless Rotary Vacuum Filter.

KILNS—DRYERS

Allis-Chalmers 8′x60′x⅝″ shell, Rotary Kiln, Falk reducer and motor.
Link Belt 7′x45′x½″ shell Rotary Kiln.
Vulcan 6′x124′x¾″ Rotary Kiln, reducer and motor.
Link Belt 604-24 Stainless Steel Roto-Louvre Dryer.
Rotary Dryer 4′x40′x⅜″, reducer, motor, new shell.
Buflovak 6″x8″ vacuum double drum Dryer.
Blaw-Knox 6′x5′6″ vacuum single drum Dryer.
F. J. Stokes Model 38A Steam heated Dryer, 16 trays.

STAINLESS STEEL TANKS

108,000 gal. closed 316 Stainless 18′x61′x¼″.
17,500 gal. closed 316 Stainless 15′x16′x⅜″.
11,500 gal. closed 316 Stainless 12′x15′x3/16″ Agit.
10,500 gal. closed 316 Stainless 10′x23′x3/16″.
4,500 gal. closed 347 Stainless, heated, 6′x25′x¼″.
4,000 bal. closed 304 Stainless, heated 8′x12′x3/16″.
3,500 gal. closed 304 Stainless, 8′x9′x5/16″.
1,200 gal. closed 347 Stainless clad 5′x8′x¼″ Agit.
750 gal. closed 347 Stainless 5′x5′x3/16″ agitated.
500 gal. closed 316 Stainless 4′x5′x3/16″.
(20) 400 to 50 gal. Type 316 and 347 Stainless Tanks.
14—Aluminum Tanks 12,000, 10,000 and 7,000 gal.
2500 gal. Pfaudler closed, glass lined, 78″x9′.

HEAT EXCHANGERS—CONDENSERS

2300 sq.ft. 564— 1″x16′ Type 316 Stainless tubes.
1000 sq.ft. 370—¾″x14′ Type 304 Stainless tubes.
800 sq.ft. 375—⅝″x14′ Type 316 Stainless tubes.
615 sq.ft. 375—⅝″x10′ Type 316 Stainless tubes.
420 sq.ft. 268—¾″x 8′ Type 304 Stainless tubes.
306 sq.ft. 130—¾″x12′ Type 316 Stainless tubes.
225 sq.ft. 96—¾″x12′ Type 316 Stainless tubes.
188 sq.ft. 96—⅝″x12′ Type 316 Stainless tubes.
146 sq.ft. 91—⅝″x8′6″ Type 316 Stainless tubes.
68 sq.ft. 22—¾″x16′ Type 347 Stainless tubes.
1860 sq.ft. *Reboiler* 271—1″x12′ Stainless tubes.
618 sq.ft. Stainless Brown *Fintube* in 77 sq.ft. units.
Pfaudler 2″, 3″, 4″ Glassed Lined *Double Pipe Coolers.*
5000 to 50 sq.ft. Admiralty and Steel Tube Condensers.

MISCELLANEOUS STOCK ITEMS

Swenson 435 sq.ft. Stainless Single Effect Evaporator.
Baker Perkins Stainless 300 gal. sigma blade Mixer.
Stokes RDS3 and DDS2 Rotary Tablet Presses.
Stokes #243E Oscillating Granulator 5 HP.
Symons 5½′ short head heavy duty Cone Crusher.
Raymond #50 and #51 Imp Mills
Squire 40″x30″ Pan Dryer, jacketed.
Buflovak jacketed 6′ Vacuum Crystallizer with plows.
Rotex single deck Sifters 60″x84″; 30″x96″.
Sweco 48″ Triple Deck Sifter, Model A9062.
Swenson 24″x20′ Stainless Crystallizers, jacketed.
Triplex Pumps 2¼x4″ 316 SS liquid end 2000 PSI.
Anders Air Dehydrator Model 8FA Automatic.
Kemp Absorptive Dryer, Model FEO2-S Dual.
Centrifugal Pumps—Stainless—1″ to 3″, 10 to 750 GPM @ 35 to 100′ head.
Fork Lift Trucks 2000 & 6000 lb., gas engine driven.
3000 ft. 24, 30 & 36″ Rubber Troughing Belt Conveyor.
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CIRCLE G ON READER SERVICE CARD

LIQUIDATIONS

CLEVELAND, OHIO

1—Raymond #73612 Super High Side 6-Roll Mill, with whizzer, cyclone, piping and motors.

1—Raymond # 6669 Super High Side 6-Roll Mill, with whizzer, cyclone, piping and motors.

1—Raymond #5047 High Side 4-Roll Mill, with whizzer, cyclone and piping

1—#1 Raymond Impact Mill, with whizzer, cyclone and piping.

1—Kilby Nickel Single Effect Force Feed Evaporators, 1200 sq. ft.
2—Oliver 5'3"x4' Nickel Clad Rotary Vacuum Filters.
2—Pfaudler 300 and 200 gal. Glass Lined Jkt. Agt. Reactors.
1—Sperry 30" C.I. Filter Press, 27 chambers.
1—Buflovak 32"x90" Dble Drum Dryer.
4—Feinc 8'x12' Rotary Vacuum Steel Filters, string discharge.
2—6'6" dia. x 60' Rotary Dryers.
1—5½'x4½'x50' Rotary Dryer.
7—Dorr 80' and 40' thickeners.
3—Vogt 387 sq. ft. Rotary Press. Filters.
2—Chicago Pneumatic 26"x14" Vacuum Pumps with 150 HP motors.
2—Fuller Kinyon Pumps H6.
1—Link-Belt 24"x90' Belt Conveyor
5—Nickel Centrif. Pumps, 2", 3".

KANSAS

1—8650 sq. ft. Forced Circulation Double Effect Evaporator, nickel clad bodies, nickel tubes, condenser, etc., UNUSED.
1—Louisville 4½' x 40' Rotary Steam Tube Dryer, 316 SS construction.
5—Glascote 500 gal. glass lined, Jacketed Reactors.
5—Pfaudler 26 sq. ft. glass lined Condensers.
1—Bird Young 18" x 24" rubber covered Rotary Vacuum Filter with Hastelloy "C" valve.
3—Lightnin Model 322-TEQ Drives, with rubber covered turbine agitators.

BRILL FOR VALUES

CENTRIFUGES

3—Bird 18" x 28", 24" x 38" Solid Bowl Continuous 304 S.S.
1—Bird 40" x 60" Solid Bowl Continuous 316 S.S. UNUSED.
5—Sharples C-20 and C-27 Super-D-Hydrator 316 S.S.
3—Sharples PY 14, PN14 Super-D-Canters 316 S.S.
2—Sharples #16, 304 S.S., 3 HP motor.
1—Tolhurst 40" 347 S.S. imperforate basket 15 HP UNUSED.

TANKS

25—500 to 3500 gal. Vertical 304 S.S. Tanks opened and closed, some agitated.
6—7500, 6000 and 2000 gal. Rubber Lined Tanks.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—2000 gal. Horizontal 304 S.S. Tank 5' x 12'.
1—2500 gal. Vertical 304 S.S. Tank 8' x 7'.
1—10,000 gal. Rubber Lined Tank 10' x 17'6".
1—5500 gal. 316 S.S. Clad Pressure Tank 250 PSI.
2—3,000 gal. Aluminum Tanks, 7' x 11'
5—25,000 gal. Aluminum Storage Tanks.

REACTORS—EVAPS—CONDS—COLUMNS

1—Pfaudler 125 gal. 304 S.S. Jkt. Agit. Reactor, 150# int., 125# jacket.
2—Pfaudler 50 gal. glass lined, Jacketed, Agitated Reactors.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—O. G. Kelly 3000 sq. ft. 309 S.S. force feed Evaporator UNUSED.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—300 sq. ft. Swenson 347 SS Single Effect Evaporator.
1—250 sq. ft. Buflovak 304 S.S. Single Effect Evaporator.
10—Stainless Heat Exchangers; 910, 536, 370, 250, 131, 70 sq. ft.
1—4'6" x 46' 316 S.S. Clad Column, 250 PSI.
8—3' x 20', 30" x 19' 347 SS Packed Columns.
1—24" x 35' 304 S.S. Bubble Cap Column.

FILTERS

1—Niagara 110 sq. ft. Vert. 316 S.S.
1—Niagara 92 sq. ft. Vert. Jkt. 316 S.S.
2—#10 Sweetland, 27 leaves 4" centers
1—#5 Sweetland 304 S.S., 120 sq. ft.
1—Oliver 6' dia. Horizontal 316 S.S.
1—Oliver 4' dia. Monel Horizontal.
1—U.S. 200 sq. ft. 304 S.S. Auto-Jet.
1—Hercules 400 sq. ft. 304 S.S. Pressure.
3—Oliver Precoat 5' x 6', 5' x 10', 8' x 10'.
1—Oliver 5'3" x 8' Steel Rotary Vac housing.
1—Feinc 3' x 1' 316 S.S. Rotary Vac.

DRYERS

1—Buflovak Vacuum Shelf, 17—60" x 80" shelves.
2—Buflovak 42" x 120", atmospheric double drum complete.
1—Buflovak 32" x 90" Atmos. Twin Drum.
2—Devine 4' x 9' single drum, atmospheric.
1—Buflovak 3' x 10' Rotary Vacuum.
6—Louisville Rotary Steam Tube, 6' x 30', 6' x 50'.
2—Louisville 8' x 50' Stainless Steel lined Rotary.
3—Rotary Dryers 6' x 50', 7' x 80", 8' x 80'.
1—Louisville 4½' x 25' Inconel Rotary.
1—Link Belt 6'4" x 24' Roto Louvre 316 S.S.
1—Atmos. Tray, 13 shelves, 3' x 3'.
2—10' and 4' dia. 304 S.S. Spray Dryers.
2—Wyssmont, 304 S.S. 6'2" and 9'6" dia.

MIXERS

1—Sturtevant 75 cu. ft. 304 S.S. Rotary Batch Blender 20 HP.
1—Abbe 110 gal. 304 S.S. Jacketed Agitated Vacuum Dispersall Mixer.
2—Baker Perkins 150 and 100 gal. jacketed double arm Sigma blades.
1—Baker Perkins 50 gal. jacketed.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
2—40 and 50 cu. ft. Powder Mixers 304 SS
2—Day 120 cu. ft. Jumbo Powder Mixers 25 HP motors.
1—45" dia. Lancaster Mixer 7½ HP motor.

MISCELLANEOUS

3—Kinney Vacuum Pumps, 1000 cfm, 10 microns, 15 HP.
3—Hardinge 6' x 36", 5' x 22" steel lined conical Ball Mills.
1—Sturtevant 6' dia. Air Separator 10 HP.
1—Komarek Greaves Briquetting Press 3½" face rolls.
3—Mikro Pulverizers, 1SH, 1SI and Bantam.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—Tyler Hummer 3' x 10' Double Deck Screens.
5—Day Roball Sifters, 40" x 120", 40" x 84", Double Deck.
6—Nash H6, H5, L5 Vacuum Pumps.
3—Nash H6, L3 347 SS Vacuum Pumps.
2—Stokes Rotary Tablet Machines DD2-DDS2.

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Stainless Suspended Type Centrifugals from 30" to 60".

2 Sharples Stainless Steel Model PN14 Super-D-Canters.

Sharples C27 Super-D-Hydrator in Type 316 Stainless; 40 HP.

2 Bird Continuous Horizontal Centrifugals; S/S & Monel 24".

2 Bird Rubber Covered Fume-Tight 48"; with Plows.

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Fitzpatrick Comminutating Machines, in Stainless; Models M, D and K.

Abbe Jacketed Steel Ball Mill; 42"x32"; with charge of balls.

Jay Bee Model T Hammer Mill; 35 Hammers; 12"x15½" Feed.

Szegvari Stainless Lab Jacketed Attritor Type SU.

Abbe No. 3 Buhrstone Lined Pebble Mill; 52"x36".

Colton Stainless Steel Rotary Granulator No. 540-15 with Stainless Sifter.

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Flash Drying System in Type 316 Stainless

Stokes Double Chamber Impregnators, 5648-5748

Nickel Clad Reactor; 7' x 11'6"; Jktd. Agtd.

Stokes Rotary DD2 Preform Press

MIXERS FOR EVERY PURPOSE

Brand NEW FALCON Ribbon Blenders; all sizes now in Stock; S.S. or Mild Steel.

Baker Perkins Heavy Duty Jacketed Mixers; from 5 gal. to 300 gal.

J. H. Day Mogul Mixer, 150 gal. Vac. Cover; 75 HP.

Day Cincinnatus Double ARM Jacketed Mixers, 75, 200, 300 gal.

LIQUIDATION CHEMICAL PLANTS FORMERLY TOMS RIVER-CINTI-OHIO

REACTORS and PRESSURE VESSELS

9—Pfaudler and Glasscote 500 gal. Jacketed and Agitated Reactors.

5—Steel Jacketed and Agitated 500 gal. Reactors.

10—Lead Lined Sulphonators in various sizes from 500 gal. up.

1—6500 gal. Welded Steel ASME Brick and Lead Lined Pressure Vessel with Agitator.

1—Lead and Brick Lined 1000 gal.

2—Lead Lined Jacketed Hi Internal Pressure, Agitated Reaction Kettle.

1—1200 gal. Rubber Lined with HAVEG Gate Type Agitator.

Cast Steel and Welded Steel Jacketed and Agitated NITRATORS, Autoclaves, Stills and Blow Cases.

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28—Vertical Condensers and Receivers manifolded together.

4—Horizontal Condensers-Receivers.

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2 Vilter 9½" x 9½" Ammonia Compressors with 100 HP motors.

2—YORK Cubice Machines with accessories.

1—VOGT Tube Ice Machines & Accessories.

1—Large Steel Hopper with Agitator 22' x 29' for receiving ice cubes.

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SHRIVER Plate and Frame Presses in Cast Iron, Wood, Monel, etc. Many with HYDRAULIC Closing Devices.

(4) 24" x 24" (50) 30" x 30"
(34) 36" x 36"

Dozens of Skeletons . . . All Sizes, Types.

69—J. H. Day Round Recessed Plate Open Delivery Presses, 18".

MILLS

Unlined Steel Ball Mills:

(2) 3' x 5' (14) 5' x 7'
(1) 4' x 6' (5) 5'3" x 7'3"
(1) 4'6" x 5'6" (1) 6' x 6'

ROD MILLS

(4) 6'4" x 6'4" (2) 5' x 4'6"

ROTARY BLENDERS

(2) 6' x 7'6"

DRYERS

19—Buffalo Model J Vacuum Chamber Dryers, 60" x 80" with 20 shelves.

8—Atmospheric Truck Dryers with Multi Compartments & Accessories.

PULVERIZERS

5—MIKRO Pulverizers Model #2 S 1.

2—Klus Fine Grind Pulverizers.

5—Raymond Model "OO" Screen Mills.

1—Raymond Whizzer Classifier.

REACTORS and PRESSURE VESSELS

Struthers Wells 2000 gal. Stainless Reactors; Jktd. and Agtd.

2 Stainless 400 gal. Reactors Jktd. & Agtd. by Struthers Wells.

6 Dorr-Oliver 550 gal. Stainless Thickeners or Reactors.

Cement Mill Machinery

from Tennessee Location

Allis Chalmers equipment for entire raw and finishing departments. Capacity 4000 Barrels per day. Mills and Separators may be purchased separately.

Two 7' x 22' Mills (two compartment)

Three 7' x 22' Mills (single Compartment)

Each of these mills have Meehanite Liners and are directly coupled to 400 HP Motors, operated in closed circuit with Three 14' Raymond DOUBLE WHIZZER Mechanical Air Separators NEW in 1950, each V Belted to 75 H.P. Motor: Also Bucket Elevators, Conveyors, etc.

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9 Gen. Elec. 20, 25, 45, 65, 70, 80, 100, 125 Ton
25-Ton Industrial Brownhoist 60' Boom Crane
200—50 Ton Box 300—70 Ton Gondola Cars
300—1½, 5, 20 & 30 yd Dump Cars
40-Ton Amer 60' Boom Diesel Loco Crane

PLANT EQUIPMENT

2—Wemco 2M-HMS Plants
No. 1—Sturtevant Hammer Bar Mill
No. 2 Robins Vertical Cone Crusher
24" x 24" Jeffrey Single Roll Crusher
No. 1 Sturtevant Rotary Fine Reduction Crusher
5' x 8' & 4½' x 9' KVS Air Swept Ball Type Mills
Ball Mills: No. 56, 5' x 5', 6' x 4', & 7' x 22'
Hardinge Mills: 3' x 8', 5' x 22" & 8' x 22"
5' x 22" Hardinge Air Sweep Ball Mill complete
Rod Mills: 4' x 11', 6' x 12' & 7' x 15'
Jaw Crushers: 9" x 24", 10" x 30", 13" x 24", 14" x 28", 18" x 36", 30" x 36", 66" x 84"
10" x 6" Sturtevant Double Roll Crusher
Crushers, Fine Reduction: 22", 2', 3', 4', 5½' x 7'
636 & 436 Allis Chalmers Hydrocone Crushers
Crushers Roll: 24" x 14", 30" x 14", 40" x 16"
Rotary Dryers: 5' x 30', 6' x 50', 6' x 70' & 8' x 80'
Rotary Kilns: 6' x 70', 7' x 110' & 9' x 160'
2—13" x 120" Buflovak Atmos. Double Drum Dryer
Roto Louvre #207-10 Type 316 S. S. Link Belt
150—1½, 2 & 4 yd & 30 yd Dump Cars
5 & 10 HP LB Car Pullers
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6—36" x 32" Dings Magnetic Head Pulleys
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FOR SALE
WYSSMONT TURBO DRYERS

5—Rotating Tray type, Model No. VTL-24, Tray. with tray and fan drives. Includes externally mounted 4-coil Steam Heat Exchanger, and motorized Blower to heat air to Dryer. Further information and price on request.

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ROTARY FLAME DRYERS In Stock

2—6' x 50' Rotary Flame Dryers ½" shell. Complete with furnace. Driven by 20 HP motor through Jones reduction unit.

Immediately Available

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Mfgd. by Babcock & Wilcox. ASME rated. 1750# oper. press.; 3572# press. tested. 650 deg. F max. temp.; Weight 80,500# Blt. 1952. Size 23' L x 53" I.D. With piping, valves, fittings, etc.

Pressure pumps—all sizes and kinds available.

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OUTSTANDING VALUES!

Ribbon blender, SS, 190 cu ft.
Simpson style UD, #2 mixer, 6' pans.
Devine #5-A, 11 shelf dryer, 40" x 43".
Williams (Zenith) 3 roll mill.

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50-52 9th St., Brooklyn 15, N. Y. HY-9-7200

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KETTLES — REACTORS

1—2000 gal. Glascote blue G/L reactor, ASME 50 psi or vac. int., 90 psi jkt.
50—1400 gal. Pfaudler blue G/L jkt. Kettles, Agit., baffles.
3—1350 gal. T347 SS kettles, open top.
13—1250 gal. Pfaudler blue G/L jkt. reactors, Agit.
1—1000 gal., T316 SS jacketed reactor, ASME, UNUSED.
1—1000 gal. Dopp cast iron kettle, 125# jacket, 15# int., Agit.
1—750 gal. Graver T304 SS jkt. fermenter, ASME 30# int., 30# jkt., 10 HP Turbine Agit.
2—600 gal. T304 SS reactors, jkt., Agit.
50—600 gal. Pfaudler Stainless jacketed kettles, open.
2—500 gal. T304 SS reactors, jacketed, ASME, Vacuum—Unused.
6—465 gal. T304L SS reactors, jacketed, 150# int., 175# jkt.
1—300 gal. T304 SS jacketed reactor, vac. ASME—UNUSED.
1—300 gal. Pfaudler blue G/L reactor, Agit., Jkt., ASME.
1—175 gal. T304 SS jkt. reactor.

MIXERS—MILLS

40—Baker-Perkins #17, 200 gal. sigma-blade, jkt. mixers.
1—Baker Perkins #15, 100 gal. Disp., T347 SS 25 HP drive.
1—Baker-Perkins #15-UUMM, 100 gal. Disp. blade, ASME jkt., 100 HP, Comp. Cover, motorized tilt.
1—J. H. Day #6, 100 gal., St. St. sigma.
2—J. H. Day #5, 75 gal., sigma.
1—Sturtevant 75 cu. ft. T304 SS blender.
2—Munson 50 cu. ft. blenders.
2—145 cu. ft. ribbon mixers.
1—Raymond 50", 5-roller hi-side, mill.
1—Raymond 66", 6-roll hi-side mill.
13—Abbe 6' x 8' batch pebble mills.
1—Hardinge 8' x 48" conical pebble.
2—Hardinge 7' x 36" conical mills.
1—Allis 6' x 12' rod mill.
1—Gemco 60 cu. ft. T304 SS conical blender.
1—Bonnot 5' x 10' ball mill, 75 HP.
3—Fitz. SS mills; D, K, F.
1—Mikro #2TH pulverizer.
2—Symons 2' cone crushers.

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(T304 UNLESS NOTED)

3—20,000 gal., 14' x 15', T316LC, cone bottom, 3/8".
2—13,000 gal. 11'-10" x 15'7".
1—12,000 gal. 9'-6" x 22', T304 SS, horiz., dished—UNUSED.
4—10,000 gal., 12' x 12', T316 SS, vert., 15 HP turbine Agit.
4—5800 gal., 10' x 10', T316 SS, turbine Agit.
5—3650 gal., 10' x 7', vert., open.
1—3350 gal., 8'x8'-6", agit., 50 psi.
1—3300 gal. 6' x 14'6", vert.
1—3250 gal., 6' x 15', T316.
7—3000 gal., 8' x 8', T316 SS, Vert., turbine Agit.
3—3000 gal., 5' x 19', T347, 60 psi.
2—2600 gal., 7' x 8', T316, dished.
1—2250 gal., 8' x 6', T316.
5—2100 gal., 8' x 5'6", dished.
1—2100 gal., 6' x 9', T316, cone.
12—1750 gal., hoppers, 4'-5" x 7'-4" x 9'-2".
4—1350 gal., 4' x 14', T347, dished, ASME 60 psi coils.
5—1350 gal., 7' x 4'-6", T321.
1—1300 gal., 6' x 6', 3/8", dished.
3—1100 gal., 4' x 11', T347, 60 psi.
3—1000 gal., 4'-6" x 8'-6", dished.
3—850 gal., 4' x 9', 3/8", dished.
1—800 gal., 5'x5'6", 1/4", dished.
3—750 gal., 5' x 5', 3/16", dished.
6—685 gal., 3' x 13', T316, coils.
3—300 gal., 4' x 3', T347, ASME 60 psi.

DRYERS — KILNS

2—Buflovak 42" x 120" double drum dryers, ASME 160# WP.
1—American 42" x 120" dbl. drum.
1—Buflovak 42" x 90" dbl. drum.
2—American 36" x 84" dbl. drum.
1—Buflovak 32" x 52" dbl. drum.
1—American 36" x 84" double drum dryer, ASME, VACUUM.
1—Buflovak 5' x 12', single drum dryer, Vacuum, UNUSED.
1—Buflovak 6" x 8" dbl. drum.
5—F. J. Stokes #138J-16, 195 sq. ft. vac. shelf dryers.
1—Buflovak 98 sq. ft. vac. shelf.
2—B. & Snow 8'-6" x 70' rotary dryers, 5/8" welded shell, late model.
1—Davenport 8' x 60' rotary, 7/16".
1—7'-6" x 62" rotary kiln, 1/2".
1—6' x 150' rotary kiln, 3/8" welded, w/burners, etc.
1—Louisville 5' x 30' steam-tube.
2—Louisville 4'-6" x 25' rotary steam-tube dryers, welded.
1—Bartlett & Snow 3' x 15' rotary dryer, Everdur metal shell.
1—3' x 23' rotary, 1/4" welded.
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1—6500 sq. ft. Swenson T316 SS 3-body, 2-stage vert. long-tube evap.
7—4050 sq. ft. calandria type evap., copper tubes, cast iron shell.
1—1250 sq. ft. Mojonnier dbl.-effect Stainless Sanitary evaporator.
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1—320 sq. ft. steel reboiler.
1—250 sq. ft. Buflovak T304 SS, single effect recompression evap.
1—118 sq. ft. Stokes T316 SS still.
1—36" dia. x 6 plate T316 SS column.
2—Vulcan T316 SS 10 plate bubble cap columns: 110", 60" dia.
6—30" x 19' T347 SS packed columns.
8—24" x 16' Duriron packed columns.
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1—1960 sq. ft. T316 SS exchanger remov. bundle, ASME 75# WP.
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5—1400 sq. ft. T316 SS gas converters.
1—900 sq. ft. T304 SS exchanger.
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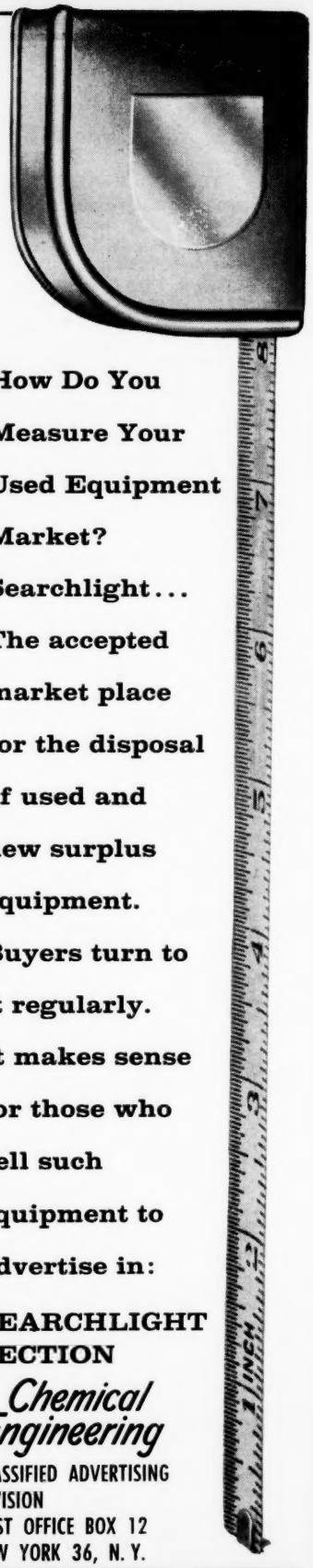

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1—Van Alst 300 gal. SS jacketed kettle.
1—300 gal. Hastelloy "B" jacketed pressure reactor.
2—Theo. Walters Hastelloy "B" 300 gal. jacketed reactors.
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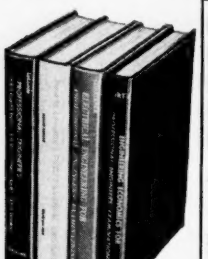

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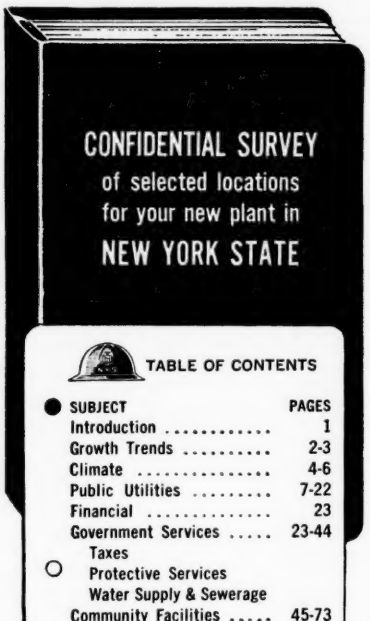

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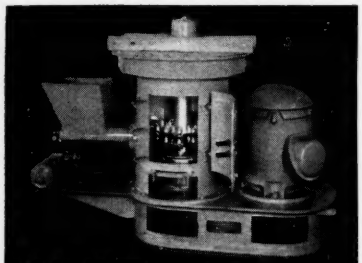

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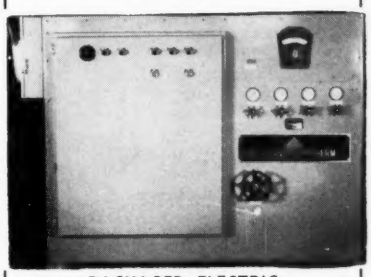

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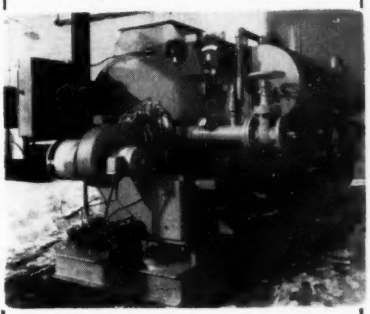

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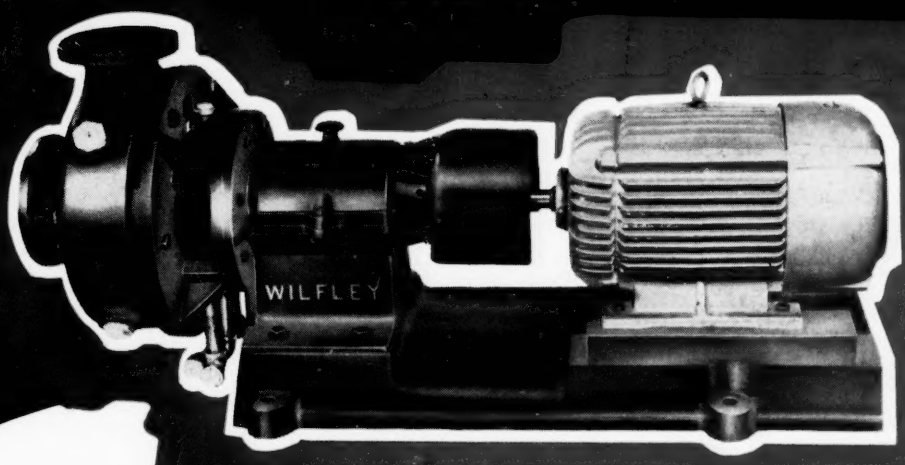

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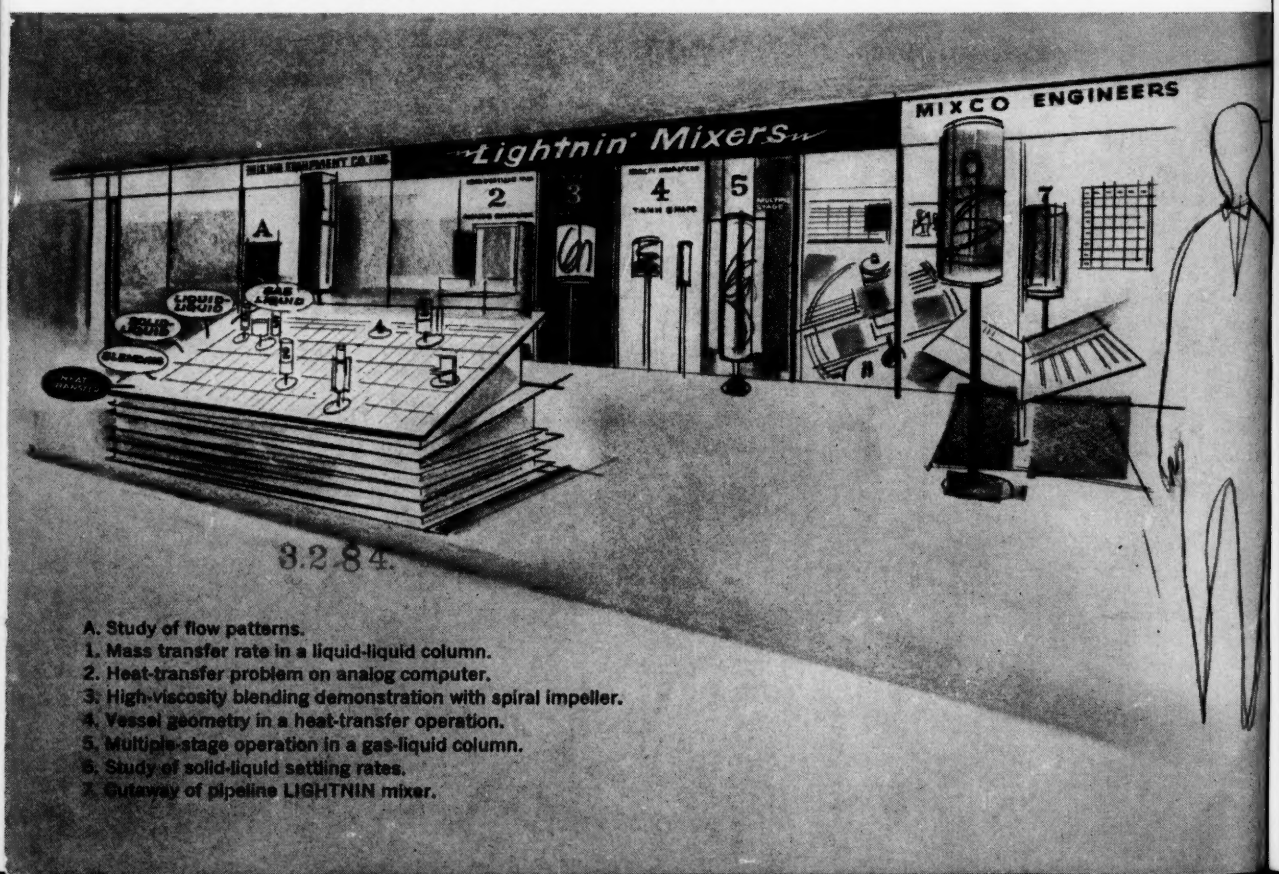

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